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INVESTIGATIONS ON

BENGAL JAIL DIETARIES

WITH SOME OBSERVATIONS ON THE INFLUENCE OF DIETARY ON THE PHYSICAL DEVELOPMENT AND WELL-BEING OF THE PEOPLE OF BENGAL.

BY

CAPTAIN D. McCAY, M.B., B.Ch., B.A.O., I.M.S.
Professor of Physiology, Medical College, Calcutta

ISSUED UNDER THE AUTHORITY OF THE GOVERNMENT OF INDIA BY THE SANITARY COMMISSIONER WITH THE GOVERNMENT OF INDIA, SIMLA.

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PART II.

BENGAL JAIL DIETARIES

With some observations on the Influence of Dietary on the Physical Development and Well-being of the People of Bengal.

INTRODUCTION.

THE investigations that have been engaging the attention of the staff * of the Physiological Department of the Medical College, Calcutta, have, we hope, shed a considerable amount of light on the nutritive value of Indian food-stuffs, and particularly on the nutritive value of jail dietaries in Bengal. They will also be found to have a very distinct bearing on the much discussed problems of nutrition.

The work recorded in this memoir has been carried out on the initiative and at the expense of the Sanitary Department of the Government of India. The importance of the subject of jail dietaries had been fully recognised by the Government of India. They had already caused certain enquiries to be made, which will be referred to, but had deferred further action until a suitable officer became available for the purpose of estimating the nutritive value of the different food-stuffs in the dietary of prisoners.

The present enquiry is limited to the jails of Bengal. The work began on the 1st February 1908 and has been going on practically continuously (so far as other official duties permitted) for the last eighteen months.

Historical.

It would not serve any useful purpose to go very deeply into the history of all the work that has been done on jail diets at Home and in India. Certain important papers will be referred to in so far as they are of interest in the light of present investigations; but all the work hitherto done has been based on the assumption that the chemical analysis of food-stuffs afforded a direct measure of their nutritive value. Further, the diet scales laid down for Indian prisons have all been calculated on the result of chemical analyses and not on the actual nutritive value of the food materials, *i.e.*, the percentage of their proximate principles that is capable of being absorbed by the intestinal tract of the prisoners

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* Three Assistant Surgeons were employed on the enquiry, *viz.* :—

Satis Chandra Banerji, L.M.S., Assistant Professor of Physiology.

Lal Mohan Ghoshal, L.M.S. }
Madan Mohan Dutta, L.M.S. } Demonstrators, Physiological Department, Medical College, Calcutta.

The present enquiry aims at estimations of the actual amount of some of th proximate principles—especially protein—that are absorbed and assimilated, an for this reason the papers above referred to, while of great importance so far as the go, do not give much assistance in the present work.

Surgeon Major T. R. Lewis* writes: "A mere tabula. statement of the severa ingredients constituting the several diets would be of comparatively little value un less accompanied by a statement of their chemical composition; and, in order t judge of the comparative merits of dietaries so analysed, it is essential that a clea conception should be formed as to what particular portions are specially adapte to the nutrition of the body." To this we may add that it is of even more import ance to know in what proportions the proximate principles of the different food stuffs are absorbed and made use of in the economy.

It is futile, for example, to work out diet scales furnishing say 80 grammes o protein per man daily, if instead of 90 per cent. only 60 per cent. of this i absorbed, and then imagine that we have provided for the prisoners' physiologica needs. Yet, so far as we have been able to find in the literature of this subjec that is what has been done hitherto.

The diet scales would also appear to have been based on those in use in the pri sons of European countries, an allowance being made for difference in weight

So far back as 1881 Lewis wrote, and it is equally true to-day:—"So fa as I am aware, no systematic series of observations has been conducte on the precise food-requirements of the inhabitants of this country when under going laborious exertion, as compared with the requirements when the body is a rest, so that all inferences as to what these requirements are, are based on experi ments made in Europe and on people accustomed to a far larger proportion o animal food than the great majority of the inhabitants of Eastern countries."

The first work done on the subject by actual experiment, to which we have reference, is an able and interesting memorandum by Surgeon Major I. B. Lyon,† Chemical Analyser to Government, Bombay. From actual experience of native prisoners on hard labour in the Bombay House of Correction, Dr. Lyon devised three scales of diet, based on the analysis of the diet on which these prisoners had been working and which had proved sufficient.

We need not go into the details of this paper: it will be sufficient for our purpose to say that the work done by Dr. Lyon was carried out from the exactly opposite point of view to that recorded in this memoir.

Dr. Lyon found that native prisoners in the Bombay House of Correction increased in health, weight and physical development when sentenced to hard labour;

* A memorandum on the Dietaries of Labouring Prisoners in Indian Jails—*Annual Report of the Sanitary Commissioner with the Government of India for 1880, page 159.*

† Memorandum by Surgeon Major I. B. Lyon, F.C.S.—*Gazette of India, 19th May 1877.*

be very properly analysed the diet on which this was possible, and found it to contain quantities of nitrogen and carbon which (when allowance is made for difference in weight) were practically identical with Letheby's estimate for ordinary labour in England, and of the same value as the hard labour diet of English convicts. On the basis of this experience his three scales of diet were formulated :—

No. 1 Scale.—The labour scale; is simply the Bombay House of Correction scale raised or lowered proportionally to the weight of the individuals to be fed.

No. 2 Scale.—The light labour scale; is scale No. 1 reduced in the proportion that the light labour diet of English convicts is lower than English convict hard labour diet.

No. 3 Scale.—The bare sustenance scale; is scale No. 1 reduced in the proportion that a mean between Edwin Smith and Letheby's estimates for bare sustenance is lower than English convict hard labour diet.

Dr. Lyon, therefore, devised his diets by working back from an analysed diet which had proved itself sufficient for all physiological purposes, *i.e.*, a diet from which enough of the different proximate principles was absorbed to supply the needs of the body. The ultimate object of the present investigation is to devise diet scales in which the several ingredients are so combined that the maximum absorption is obtained with a minimum of waste—a point not taken notice of in either Lyon's diets or any other diet scales that have been framed for Indian jails.

The reason why dietaries for prisoners in India have all been worked out from the chemical analyses of the foods in use appears to be that, from the investigations that have been carried out in Europe and America on the percentage absorption of the proximate principles, a fairly fixed proportion of these was found to be absorbed, *i.e.*, above 90 per cent. in a mixed animal diet and above 85 per cent. in a so-called vegetable diet. So that, by assuming these percentages to hold good for Indian food-stuffs, the framers of the different diets estimated that between 85 and 90 per cent. of the proximate principles found by chemical analysis in the diets would be absorbed. This we shall show is not by any means the case; and, further, we shall give abundant evidence that the actual amount of absorption does not vary directly with the quantity of the proximate principles contained in the diet; this at least we can strongly assert is so in the case of the most important of the proximate principles—protein. It was a very natural assumption to make and, so far as we know, the fallacy was not discovered until actual examination* of the excreta of prisoners on a known jail diet proved that a comparatively poor absorption of protein takes place when the actual amount of protein offered in the diet is taken into consideration.

* Scientific Memoirs No. 34.—Standards of the Constituents of the Blood and Urine and the Bearing of the Metabolism of the Bengali on the Problems of Nutrition.

The next paper to which we wish to refer is Surgeon-Major T. B. Lewis's Memorandum * on the Dietaries of Labouring Prisoners in Indian Jails. This is a most important and comprehensive discussion of the whole subject of Indian jail dietaries. Dr. Lewis evidently clearly foresaw the importance of the absorbability of a diet, for in discussing the nutritive value of the diet scales of labouring prisoners he says. "There are practical difficulties in deciding the equivalent values of these various food-stuffs, not only because the chemical analyses which have been made of many of them are not so complete as desirable, but there is also a want of definite knowledge as to their exact position as true aliments based on their adaptability for being assimilated."

This valuable memorandum traces the history of the different scales of diet for Indian prisons and gives their values in the principal alimentary constituents.

Thus the Government of Bengal in 1860 adopted certain scales on the recommendation of Dr. Mouat. The interesting point regarding these diets for labouring and under-trial prisoners is that animal food was included. These diets appear to have been in force in Lower Bengal for eighteen years. Their chief constituents are worth recording :—

Rice	20·5 ozs.	Rice	20·5 ozs.
Meat	4·1 ,, (4 days).	Fish	4·1 ,, (4 days).
Dal	4·1 ,,	Dal	4·1 ,,
Vegetables	4·1 ,, (8·2 ozs. 3 days).	Vegetables	4·1 ,, (8·2 ozs. 3 days).

Computed by Lewis to be equivalent to practically 14 grammes of nitrogen or 87·50 grammes of protein daily.

When compared with the scales of diet which have been adapted from the English local prison scale for men of an average weight of 110 lbs., it will be found that the amount of nitrogen in each day's food in the scale for Bengalis is precisely the same as is contained in the "adapted" maximum scale, 205 grains. The amount of carbon is greater by over 800 grains.

The diet scale for natives of Behar is considerably more liberal as 10 ozs. of wheat was substituted for 8 ozs. of rice. The chief constituents of these diets are also of interest :—

Rice	12·3 ozs.	Rice	12·3 ozs.
Wheat Ata	10·2 ,,	Wheat Ata	10·2 ,,
Meat	4·1 ,, (4 days).	Fish	4·1 ,, (4 days).
Pulse (Dal)	2·0 ,, (4 days).	Pulse (Dal)	2·0 ,, (4 days).
	6·1 ,, (3 days).		6·1 ,, (3 days).
Vegetables	4·1 ,,	Vegetables	4·1 ,,

Computed by Lewis to be equivalent to 16·80 grammes of nitrogen or 105 grammes of protein daily.

*loc-cit.

In 1877 another Jail Conference was assembled in Calcutta when it was found that such diversities existed as to the quantities and nature of the food given in different jails that it was deemed expedient to make an attempt to introduce a new scale of dietary. Excluding the recommendations regarding vegetables, fats, salt, etc., the following scale was laid down as a maximum for adult male prisoners sentenced to hard labonr.

26 ounces (including 4 ozs. pulse) of sifted *flour*, and 28 ozs. of *grain* in the case of wheat, rice or barley.

Whenever it may be considered necessary 4 ozs. of meat or fish, or an equivalent of milk, may be given instead of 4 ozs. of grain.

As Dr. Lewis points out, the principal difference between these diets and those recommended by the 1864 Committee consists in the adoption of the principle that the issue of animal food should be left to the discretion of the local jail authorities, instead of making it a compulsory article of the labouring and under-trial dietary. On the whole there is practically but little difference between the recommendation of the Committee of 1864 and of the Conference of 1877 so far as the ultimate chemical constituents of the dietaries are concerned; but a pound of animal food per week constituted part of the regular food approved by the former, whereas the latter left the issue of this article to the discretion of the local authorities. The Conference, however, increased the rice ration by four ounces daily when meat was not given, and the vegetables were increased by two ounces per diem.

Lewis says that in March 1879 the Bengali and Behari prisoners were placed on the diet proposed by the Conference and he continues thus: "During this year the health returns of the prisoners in Bengal were exceptionally unfavourable; and as the period during which the new dietary was in force coincided with the period of maximum mortality, it was concluded that the high sickness and mortality in this particular province was attributable to insufficient food. In consequence of this inference extra rations were issued from March 1880 to July 1881 when completely new scales of diets were introduced with the sanction of the Local Government."

In July 1881 the dietary scale introduced for Lower Bengal was :—

Rice	22 ozs.		4 ozs. of meat or fish could be substituted at the option of the jail officer for 4ozs. of pulse on four days per week.
Pulse (Dal)	6 ,,		
Vegetables	6 ,,		
Oil	½ ,,		
Gram	3 ,,	morning meal	
or			
Rice	4 ,,		
Molasses	1 ,,		
Tamarind	½ ,,		
Salt	½ ,,		

The scales for Bengalis and Beharis were alike, with the exception that the staple cereal in the dietary of the Behari consisted of a mixture of 12 ozs. rice and 10 ozs. wheat flour or a similar mixture of rice and maize.

Lewis remarks on these diets that, "taken as a whole, the nutritive value of this dietary not only exceeds, under every heading, the 'adapted' scale, which has been prepared from English Local Prison scales, but, in most cases the amount of food actually issued is more than is given as a maximum dietary in either the convict or the Local Prisons in England and Wales. Computed on the English standard these scales should suffice for men weighing considerably more than the average weight of natives of Bengal and of Behar — the Bengali scales for a body-weight of from 123 to 150 lbs.; and the Behari scales for persons weighing 140 to 172 lbs."

We need not follow Dr. Lewis in the discussion of these diet scales further than to note that he shows that, on a dietary much inferior to this 1881 scale, Burma prisoners were exceedingly healthy and over 85 per cent. gained in weight. He further instances, as an illustration of the caution that should be observed in attributing exceptional sickness and mortality amongst prisoners to insufficient food alone, the experience furnished by the Punjab jails. The mortality in certain of these jails was unprecedentedly high although the special dietaries sanctioned were practically double the ordinary scales.

Further, the fluctuations in mortality seem to occur quite irrespective of the nature of the dietary and no appreciable result followed the issue of specially liberal scales of diet. Nevertheless, as will be gathered from the records of the history of jail diets in India, there seems to have been a gradual increase in the quantities of the several food-stuffs sanctioned, in the majority of cases to meet exceptional sickness and mortality, while the sanitary conditions were never thought of. The whole idea seems to have been to fortify the body against infection by means of continually increasing the food intake—specially the nitrogenous intake—and no one at that time ever thought of making any attempt at removing the source of infection—at least we have no information of any such attempts. The teaching of Liebig had a marked influence in these increases of jail diets and very great prominence was given to the necessity of increasing the albuminous or nitrogenous principles of food in proportion to the amount of work exacted, on the supposition that the nitrogenous, chiefly muscular, tissues of the body are rapidly wasted as a result of exertion, and that the non-nitrogenous elements of food were simply useful in the production of heat. In the endeavour that had been manifested by many framers of jail dietaries to raise the proportion of the nitrogenous element a large addition to the pulses had been a favourite mode of meeting the requirements; but, as Lewis pointed out chemical analysis, however exhaustive, can only afford such information as will enable an approximate estimate to be formed of the nutritive value of any food, seeing it is not only what nutriment a particular

food-stuff contains that is of moment, but also what portion of it can be readily digested and assimilated by the body. He adds that it is very doubtful whether the increase in the nitrogenous elements by raising the proportion of the pulses—and specially if badly cooked—is of any advantage, and perhaps may even be injurious.

Dr. Lewis concludes this critical study of Indian jail dietaries by expressing the opinion that, so far as the actual quantities of proximate principles are concerned, the scales sanctioned have not been insufficient. On the contrary, native labouring prisoners in every province in India have been, weight for weight, better fed than either convicts or other prisoners in England. He shows that the lowest scales are by no means associated with the most unfavourable health-returns, but that, on the contrary, in those instances where enquiry has been made, the results in this respect were even better than those associated with the most liberal diets. The diet that he suggests as sufficient for the maintenance of native prisoners in good health and at the same time compatible with the exaction of a fair amount of ordinary hard labour is :—

Protein	3 ozs.	=	85·08 grms.
Carbohydrate	$18\frac{1}{2}$ „	=	524·66 „
Fat	$1\text{-}1\frac{1}{2}$ „	=	28·36—42·54 grms.

with the usual condiments, salt, etc.

This diet he bases on the maximum diet scale of English Local Prisons, correcting the several quantities for the difference in weight between English prisoners and native Indian prisoners. It corresponds very closely to the diet given by Lyon for the Bombay House of Correction.

Expressed in the manner given above as so many grammes or ozs. of alimentary principles we have no criticism to make : the scale is, so far as our knowledge goes, quite sufficient, in fact, probably greater than is necessary. It is the method by which these standards for native prisoners are arrived at, and the deductions that have been drawn from their effects that seem to us fallacious.

It is not possible to deduce a standard of diet for natives of India from the estimations of the proximate principles of dietaries that have been found suitable and sufficient for European prisoners. If the proximate principles of the materials making up the Indian diets were absorbed in the same proportion as is the case in European diets, we grant that this method of calculating their nutritive value and this estimation of the quantities required would be permissible. But the absorbability of the ultimate alimentary principles of Indian food-stuffs is very far from being identical with that of European food-stuffs—at least when the former are given in the quantities necessary to make up the proper amounts of those principles.

So that to have estimated the amounts of protein, carbohydrate and fat in a satisfactory European diet and then, by calculations based on the chemical analyses of Indian food materials, to work out the combinations of those food-stuffs that will provide the identical amounts of protein, carbohydrate and fat, will give us a diet that, by chemical analysis, is identical as regards the quantities of alimentary principles present, but one from which a very dissimilar amount of nutritive material is capable of being absorbed.

As we have already said—and to this point we shall have to return—even the comparatively inferior European food materials show an absorptive co-efficient of 85 per cent. while the superior Indian food-stuffs' co-efficient rarely exceeds 60 per cent. when they are given in the quantities laid down in the jail dietaries we have examined.

The fallacy therefore comes in that, in giving any of these dietaries which have been framed to provide more or less identical amounts of the different proximate principles that have been in use in Europe, instead of obtaining a similar degree of absorption a very much lower amount of the nutritive value is made use of; so that what is thought—for instance, in a diet such as would be framed on Lewis's standard—to give a metabolism of over 70 grammes of protein per man daily in all probability would really only give a metabolism of just about 50 grammes of protein.

As we shall have evidence to bring forward on this later, at present it is sufficient to say that one of the important causes of this poor absorption is the fact that, in order to provide a diet containing anything approaching the standards of European diets in proximate principles, so much of the Indian food materials has to be given that less than the optimum absorption takes place, the mere bulk interfering with absorption.

Another point which is clear from what we have said above in connection with diets framed on European experience, is that, having provided a diet of Indian food materials that contains a similar amount of the different alimentary principles, and having found by practical experience that such a diet is sufficient for all the physiological requirements of labouring prisoners, and knowing that this Indian food diet only permits of say 50 grammes of protein being absorbed while the European (identical in proximate principles but made up of different food materials) permits of 70 grammes being absorbed daily, it is surely possible so to arrange a dietary that it will provide for the absorption of 50 grammes of protein and a sufficiency of all other constituents without having to lose 20 grammes of protein per man daily as compared with the European prisoner. This also is a subject to which we have devoted a good deal of attention.

While making these criticisms on the dietaries that have been framed for Indian prisoners, and particularly on the work of Lyon and Lewis, we have no wish

to detract from the value of their researches for which nothing but admiration is possible. No work had been done in their time on the actual nutritive value of Indian food materials, *i.e.*, the amount actually absorbed from the dietaries—a circumstance that clearly handicapped Lewis, and one to which he refers more than once—it is not to be wondered at, therefore, that the framers of diet scales should make use of the only means open to them in their work, and base their standards on those diets which had been found successful in practice.

The next paper to which reference is necessary is an extremely able article* on, and critical review of, the subject of Indian jail dietaries by Major R. J. Macnamara, I.M.S., in 1906. This report, submitted to the Punjab Government, was to some extent the starting point of the present enquiry as, in transmitting it to the Government of India, His Honour the Lieutenant-Governor of the Punjab enquired whether the Government of India were disposed to extend the investigations to other provinces.

In this very valuable report Major Macnamara deals more particularly with the diet scales of the Punjab, which he considers to be much too high, and suggests new scales of diet based on the work carried out by Dunlop on the Prison Dietaries of Scotland.

In so far as our investigations touch the food-stuffs in use in the Punjab we are in absolute agreement with Major Macnamara, and we can heartily endorse his remarks on the dietaries of the jails of Bengal.

For the same reason, but to a somewhat less extent, this most valuable report from other points of view, is not of much service in our investigations in Bengal. It deals to a large extent with the theoretical side of the question and with the framing of dietaries adapted to Indian jail conditions on the basis of those found satisfactory in Scotland. It differs, however, in one important particular from either of the papers already referred to, in that the diets on which Major Macnamara has based his adaptations were worked out from the standpoint of the actual nutritive value of the food materials, and not from their gross chemical composition stated as so much protein, carbohydrate and fat. This we consider is the only rational method of approaching the subject of the framing of diet scales. It is futile to talk of the nutritive value of a diet—such as the Bengal diet—as being superior to an English standard diet, because it offers 42 grains more nitrogen per man daily, if less than 60 per cent. of the nitrogen of that Bengal diet is absorbed whilst 90 per cent. of the nitrogen of the English standard diet undergoes metabolism in the system. It is because in India we are dealing with classes of food-stuffs largely different from those in use in European countries, and more particularly with very different quantities of any ingredient

* Notes on Indian Jail Dietaries with special reference to the Punjab by Major R. J. Macnamara, I.M.S., 1906.

common to the diets of both countries, and perhaps also with a people who have a low power of absorption as compared with Europeans, that we consider that any adaptation based on European experience is misleading and incorrect.

To much of the valuable information contained in Major Macnamara's paper we shall have occasion to refer when dealing with other parts of the enquiry, at present all that we need say is that, until the Punjab jail diets have been studied from the standpoint of their actual nutritive value, it is impossible to form any opinion as to their superiority or otherwise, compared with Major Macnamara's adaptations based on the Scotch dietaries.

With regard to the remarks of Lieutenant-Colonel C. J. Bamber, I.M.S., Sanitary Commissioner, Punjab, we cannot do better than quote his closing paragraph: "In conclusion, I think it will be advisable before making any alteration in the diet scales of the Province to appoint a Committee to consider the diets of the people of the different districts of the province, to carry out experiments on the chemical composition and digestibility of the different food grains in use in this Province, and then, having fixed upon suitable diet scales, to try them first in one or two jails in this Province."

The last of the official papers connected with this subject is the correspondence relating to the dietary in force in the Andamans. We shall have occasion to make use of the experience gained as to the suitability of the diet scales in force in that Settlement when we come to consider the proper proportions of the different food-stuffs constituting satisfactory diets.

The Scope of the Present Enquiry.

The following extract from a letter from the Sanitary Commissioner with the Government of India to the Government of Bengal gives an outline of the work required to be carried out :—

"To begin at once the investigation into the suitability of the diet scales prescribed for prisoners in the jails of Bengal. He should be required to estimate the actual nutritive value of the different food-stuffs entering into the dietary of the prisoners ; this will involve—

(1) Chemical analyses of the foods.

(2) An estimate of the quantities of each proximate principle in the diet scales.

(3) Chemical examination of the excreta.

(4) Chemical examination of the blood.

(5) Also to enquire into the effects of the different kinds of dal on nutrition and on intestinal disorders.

(6) The effects of the large amount of carbohydrate on nutrition and on intestinal disorders.

(7) The effects of the large quantity of salt which is at present given to prisoners."

As will be evident a pretty extensive programme was outlined for our guidance in the investigations. Some of the points we have been barely able to touch on, while others have been very thoroughly enquired into.

The estimation of the nutritive value of the dietaries has turned out to involve a very great deal of work and has taken up at least 90 per cent. of the time that could be allotted to the enquiry from official duties. This part of the work is by far the most important and of the greatest interest. So far as India is concerned it is entirely new—except for observations * on four prisoners in the Presidency Jail, Calcutta, already referred to; these were on prisoners who were getting fish in their diet and are not quite comparable with what is found in the case of a strictly vegetarian diet. A good deal of work has been done on the Continent and in America on estimations of the nutritive value of separate food-stuffs and of mixed diets, and it was thought that by making use of the same methods as employed in those investigations, this part of the enquiry would be a comparatively simple matter. Such, however, did not prove to be the case; it was found that new methods of investigation had to be devised, to meet the difficulties encountered in applying the old methods to diets composed almost entirely of vegetable matter and showing an exceeding low co-efficient of absorption.

In the work hitherto done on the nutritive value of food-stuffs and dietaries in America and Europe the materials under investigation all show a very high percentage of absorption for the several proximate principles. Thus Rubner and Atwater's † figures give—

Meats, Fish, Milk	91—95 % of protein absorbed.
Maize	89 % " " "
Rice	84 % " " "
Peas	82½% " " "
Beans	70 % " " "
Whole Wheat Bread	69½% " " "
Potatoes, Cabbage, Carrots	61—81½% " " "

* Scientific Memoirs, No. 34.

† Food and the Principles of Dietetics, R. Hutchison, M.D.

Without going into detail of the investigations carried out on absorption in these countries we may say with Hutchison that, "taking the general results of all experiments, it is calculated that the following proportions of the nutritive constituents will be absorbed from a mixed diet"* :—

	Protein.	Carbohydrate.	Fat.
Animal foods . .	. 98%	100%	97%
Cereals and Sugars .	. 85%	98%	90%
Vegetables and Fruit	. 80%	95%	90%

Later experiments, particularly in America, appear to give lower figures specially for the cereals and legumes ; however, we may accept it that the co-efficient of absorption is very high.

These results were obtained from experiments on batches of one, two, three or four men observed for one, two or more days. The batch was put on a "basal" diet—a known diet from which a known amount of protein, carbohydrate and fat would be absorbed ; then to the basal diet the food material to be examined was added. By calculation from the result of chemical analysis of the excreta before and after the new food material was added the co-efficient of absorption of the proximate principles is obtained in the usual way. This is the method—introduced by Bryant and Milner—that we made use of in our investigations. It was modified to suit the special conditions of our work.

By this method or others on the same lines, the co-efficient of absorption of the alimentary principles of the separate food-stuffs composing a diet in Europe and America have been worked out, and fixed figures are published representing the percentage of protein, carbohydrate or fat that is absorbed from any of the food materials in use in those countries. Thus for protein according to Atwater† we find the co-efficient of digestibility given for the several classes of food as follows :—

Soups . . Meats . . Fish . . Eggs . .	co-efficient of digestibility 97%
Cereals . . Bread . . Crackers (biscuits) Vegetables . . Fruit . .	,, ,, 83—85%
Legumes (average)	,, ,, (about) 76%

The results of our investigations would appear to show that no fixed figures for the co-efficient of absorption—at least for protein—of the different food

* Hutchison, page 14.

† Atwater: Storrs Agricultural Experiment Station, 9th Annual Report 1896.

materials can be arrived at so far as Indian jail dietaries are concerned. The percentage of the protein absorption of the whole diets—and this applies to the individual parts composing the diet—was found to vary very largely with the actual quantity or bulkiness of the diet.

In diet scales in force in America and Europe the question of bulk hardly comes into play—the diets are very much concentrated and are never sufficient in quantity to cause distension of the stomach, while the contrary is the usual condition in all jail diets in Bengal. This question of bulkiness is a very important one from the standpoint of the absorbability of a diet. It is an attribute common to all vegetable foods, and, when we say that the average weight of the food (cooked) consumed in a day by a Bengali prisoner is somewhere about 140 ounces and its bulk more than sufficient to fill a good sized hand basin,* it is not to be wondered at that the diet is bulky out of all proportion to the amount of nutriment it contains. Nor is it to be wondered at that this bulk interferes with its digestion and the absorption of its proximate principles: this is due largely to the difficulty experienced by the digestive juices in penetrating such a mass, and to dilatation and weakening of the walls of the stomach with an accompanying loss of power in passing the mass on and causing it to be mixed with the gastric juice. But, perhaps, even more important is the fact that the large mass stimulates and hastens the intestinal movements, so that the contents are hurried on—absorption being thus inefficiently carried out.

We found very early in the investigation that the question of bulk was a most important one from the standpoint of the nutritive value of the dietaries of Bengal jails. In fact, amongst the first set of experiments made were those in which the ordinary quantity of rice was increased in one batch of prisoners whilst in another batch it was diminished; the results showed that increase of bulk, by the addition of more rice, caused a diminution in the actual amount of protein undergoing metabolism whilst diminution in bulk had the opposite effect. It is not therefore, to be wondered at that, when we took the ordinary jail diet as our "basal diet" and added more of any one ingredient of that diet, instead of obtaining figures for the co-efficient of absorption similar to those given by the observers above-mentioned, we got a negative quantity. Further, we found that by diminishing the quantity of any of the ingredients, such as rice, not only was there an increase in the relative amount or percentage of the protein absorbed, but that there was also an increase in the actual amount of protein undergoing metabolism. It was only after reducing the amount of the ordinary jail diet until the protein absorbed from it approached the lower limits of nitrogenous equilibrium that

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* Twenty-six ozs. of dry rice when cooked measure about 2800 c.c., even when lightly packed in a cylindrical glass measure.

we were able, by using Bryant and Milner's method, to get figures for the co-efficient of protein absorption that were at all comparable with those of Rubner, Atwater, etc.

We found that for different quantities of the food-stuff in the diets examined different proportions of their contained protein were absorbed, and that, instead of finding a figure that represented the percentage of protein absorbed for varying amounts of rice, wheat, dal, etc., for each separate quantity of rice, wheat, dal, etc., above a certain amount, a different percentage of its contained protein would be absorbed. This is a very different result from what would appear to be the case from the work of investigators in Europe and America; but it is covered by a simple explanation. If we assume that 85 per cent. is the maximum of protein absorption possible on a diet of cereals and legumes, then, under ordinary physiological conditions, that 85 per cent. will be absorbed; this is what takes place in the class of diets in which investigations on the co-efficient of protein absorption have been carried out in America and Europe—the quantities added to the basal diet have never caused the total diet to exceed the amount the stomach and intestinal juices were capable of dealing with.

Now, when a gradual increase in the quantity or mass of the diet is made, after a time there is reached a point at which the mass or bulk begins to interfere with absorption, and any further increase causes greater and greater interference, so that there is a fall in the percentage of protein absorption from the assumed 85 per cent. to a much lower figure whose value depends on the greater or less interference that has taken place; this is what we have found to be the case in the dietaries of the Bengal jails—the quantities of the several food-stuffs overstep the physiological limits with the result that absorption is greatly interfered with and, instead of having an all round absorption of about 85 per cent. as obtains in Europe on vegetable diets, we have an absorption from the ordinary jail dietaries that barely touches 55 per cent. What is true for these diets as a whole is equally so for the different food materials composing the diets, whether these be rice, wheat ata or dal.

For these reasons early in the investigation we had to give up all idea of discovering more or less constant figures that would represent the percentages of protein absorption from the different food-stuffs composing the jail dietaries. If such constants had been found then the arranging of jail diets based on the real nutritive value would have been a fairly simple matter. As owing to the above-mentioned circumstances this method was found impossible we next turned to the variations in the nutritive value of the diet scales as a whole in order to discover what combination of the several items of the diets gave the most favourable results, and in what quantities these several items should be combined. It will be fairly

evident, assuming as before that 85 per cent. of the protein of rice is absorbed so long as the quantity of rice does not exceed a certain amount, that if we increase the quantity of rice beyond this amount, even if a smaller percentage of the protein is absorbed, the now greater quantity of protein from the increased amount of rice multiplied by a slightly diminished co-efficient of absorption will give an actually greater quantity of protein undergoing metabolism in the body. This will hold true up to a certain limit and when this is passed, the actual amount of protein undergoing metabolism will diminish instead of increasing as more and more rice is added to the diet. An illustration will make this line of reasoning clear :—

> Supposing 5 grammes of nitrogen in the form of rice to be the maximum amount from which full absorption takes place, then $5 \times 0{\cdot}85 = 4{\cdot}25$ grammes is the amount of nitrogen undergoing metabolism.

Now assume that for every increase of 1 gramme of nitrogen in the form of rice there is a fall of 10 per cent. in the co-efficient of absorption then :—

6 grms. nitrogen	× ·75	gives	4·50	grms. undergoing metabolism
7 ,, ,,	× ·65	,,	4·55	,, ,, ,,
8 ,, ,,	× ·55	,,	4·40	,, ,, ,,

so that we obtain the maximum absorption in our illustration with 7 grammes, and the amount of rice present in the diet from which this maximum absorption takes place we may call the *optimum amount* ; of course, it is understood that all other constituents of the diets remain constant.

Basing our investigations on this principle we have worked out the optima amounts of the different food-stuffs made use of in the dietaries of Lower Bengal and Behar, and plotted our results out in the form of curves of absorption under varying quantities of each different food material whilst all other constituents are kept constant. It will be readily admitted that, having found the particular quantities of the different food-stuffs from which the greatest amount of protein is absorbed, we have got the particular quantity of each food-stuff that is the most useful to the body, and, therefore, the most economical so far as that type of diet is concerned ; and, by combining those quantities of the food-stuffs available in Bengal and Behar, we get diet scales based on the real nutritive value of the foods of the country. It will be evident that investigations carried out on this plan entailed an immense amount of work as compared with the simpler methods in use in Europe and America. Instead of our being able in a few experiments to obtain the nutritive value of a "basal diet" and then add rice, wheat ata, different dals or makkai ata to it, and calculate from the percentage of the extra amount absorbed the co-efficient of protein absorption for each food-stuff, for every food-stuff a whole series of experiments had to be carried out to obtain its curve of absorption under varying conditions.

Thus for wheat ata in the Behar diet we had to arrange for a series of diets on the following plan :—

$$\left.\begin{array}{l} x \text{ Rice} \\ y \text{ Dal} \\ z \text{ Vegetables} \end{array}\right\} \text{Constant} + \ldots \left\{\begin{array}{llll} a & \text{Wheat} & \text{ata} & \text{Diet I.} \\ b & ,, & ,, & ,,\ \text{II.} \\ c & ,, & ,, & ,,\ \text{III.} \\ d & ,, & ,, & ,,\ \text{IV.} \\ e & ,, & ,, & ,,\ \text{V.} \end{array}\right.$$

[Each of these diets entailed one week's work]

a, b, c, d, and e are gradually diminishing quantities. And the same had to be done to get the curve of absorption for the protein of rice and to a smaller extent also for dal. To have done this for all the different kinds of dals in use would have taken months of work, and more time than we could spare ; it was, therefore, carried out for two of the principal dals, and by other methods of investigation the relative nutritive value of the other kinds of dal was estimated. Besides investigations of this nature to discover the quantities of the food-stuffs and the combinations of those quantities from which the maximum absorption is obtainable, many other observations on the effects of meat, fish, wheat ata on Bengalis, etc., were carried out. Some most interesting results were obtained, amongst the more important of which were the influence that an animal protein exerts in causing an increase in the protein absorption seemingly out of proportion to the amount of protein it contains, and the favourable influence that wheat ata has on protein absorption when it is added in small quantities to the ordinary Bengali diet.

We have discussed the nutritive value of Indian jail dietaries nearly always from the point of view of the absorption of protein, leaving the carbohydrates and fats out of consideration. This is due to the fact that protein is of pre-eminent importance in a diet. Major Macnamara sums up the reasons for attaching much greater importance to protein than to the other proximate principles as follows :—

1. A certain amount of nitrogenous substance must be present in all dietaries, and cannot be replaced by any other aliment.
2. All nitrogenous articles of diet also contain carbon, whilst all carbonaceous substances do not contain nitrogen.
3. All diets composed largely or entirely of vegetable substances, such as are those of the natives of this country, are not likely to be deficient in carbon if the nitrogenous principles are present in sufficient amount.

We shall have more to say regarding the excess of carbohydrate in the Bengal jail dietaries when we come to the work dealing with the composition of those dietaries.

At present it will be sufficient to point out that abundant experimental evidence has accumulated to show that the nutritive values of the fats and carbohydrates of food are almost proportional to the amount of energy that they can furnish; consequently it is only important that the quantity of either or both be such that their total energy, when added to that of the protein of the diet, shall supply the amount required by the body. The maximum amount of energy that can be obtained by the body is not the total potential energy of the food consumed, since the potential energy of the corresponding fæces must be deducted. Furthermore, the body is not capable of completely oxidising the absorbed protein, the incompletely oxidised products being excreted in the urine, and the energy eliminated in this way must also be deducted. The net or actual energy-value to the body is the total potential energy of the food *minus* that of the corresponding fæces and urine.* In dealing, however, with the vegetarian dietaries in force in Indian jails another factor has to be considered with regard to the energy or fuel value of a diet; this factor is the excessive fermentative processes in the digestive tract. Anyone who has experience of the effects of excessive carbohydrates in the diet will readily recognise the clinical features of excessive intestinal fermentation in the noisy eructations, flatulency, tendency to diarrhœa and colic and, above all, the changes in the appearance and character of the fæces—soft from admixture with gas, and light brown to yellow in colour for the same reason—exhibited, sometimes in a marked degree, by the prisoners examined by us.

This excessive fermentation of carbohydrates constitutes an important source of loss of potential energy of the diet, through the conversion of sugar or starch into carbon dioxide and fermentative products of low caloric value, such as acetic acid, lactic acid, etc.

This loss, which may be large in amount depending on the degree of fermentation present, will reduce the fuel value of the diet very considerably, and may afford a likely explanation of the remarkable want of body fat in many of the ordinary working population of Bengal. The loss of fuel from fermentation being so considerable that, although the diet is exceedingly rich in carbohydrate material, none or only a minimum can be stored and even in some cases where under-nutrition is well-marked, the body tissues are drawn on to meet the caloric requirements. This method of waste due to excessive carbohydrates in the jail dietaries of Bengal is, we believe, a most important factor and one that must be taken into consideration not only in calculating the fuel value of the diets but also in connection with the intestinal troubles that are so prevalent in Bengal jails and indeed amongst the people generally.

So far as we know there is no method by which this loss can be even approximately computed; but that it is an important factor in reducing the fuel value of

* The narrative requirements of the body. Benedict, American Journal of Physiology, Vol. XVI, No. IV.

the food will be readily admitted; and it, therefore, introduces a fallacy into any determinations of the energy requirements by the respiration calorimeter under conditions of excessive fermentation.

No work has been done in India on the determination of the energy requirements of Indians of different size, age, sex and degrees of bodily activity. Accepting that the law of the conservation of energy obtains in the human organism, such work will require the determination of the energy-output per day in terms of the total heat-output by means of the respiration calorimeter. Any calculation of the heat-value obtained from the food that is based on the number of heat units furnished by that food must, therefore, take into account the loss in the urine and fæces, and the loss incidental to fermentation in the gastro-intestinal tract. We have no observations on the total loss of heat in the urine and fæces of prisoners on any of the diets investigated and, as stated above, there is no means of determining the loss due to fermentation.

We are, however, able to present the energy values of the different food-stuffs in use in the jails of Bengal determined by means of the calorimetric bomb. For these results we are indebted to the kindness of Professor Benedict of the Carnegie Institute of Washington, Boston, who, on hearing of these investigations, at once offered assistance in the determination of the energy values of the food-stuffs. To Professor Benedict we desire to express our thanks for the kindly interest he has taken in the enquiry and for the help he has rendered us.

We shall conclude what we have to say regarding the scope of the present enquiry by giving a short, concise

Account of the work done.

1. All the different food-stuffs in use in the dietaries of Bengal and Behar jails have been analysed. As will be seen from the tables of analyses this involved a good deal of labour; but in addition to these, which were all carried out at the beginning of the investigation before work on nutritive value was commenced, we almost invariably analysed the different food materials entering into the composition of the dietaries whose nutritive value was being examined. This was found necessary in order to obtain an accurate estimate of the total protein intake; the nutritive investigations being carried out during both the wet and the dry seasons of the year differences in the percentage of moisture caused considerable variations in the percentages of the different proximate principles.

This part of the work entailed about—

300 Kjeldahl's estimations of total nitrogen.
180 determinations of carbohydrate.
130 „ „ fat.
50 „ „ moisture.
50 „ „ ash.

In all 60 different samples of food-stuffs, obtained from seven different jails in Bengal, were analysed.

2. Investigations were carried out in the following Bengal Jails :—

Presidency Jail, Calcutta; Central Jail, Midnapore; Puri Jail; Central Jail, Buxar; Central Jail, Bhagalpur; Ranchi Jail; Motihari Jail and Darjeeling Jail. Thus the different peoples of the Province were all included.

3. The number of prisoners in the different jails who were under observation in the investigations were :—

Presidency Jail, Calcutta.

5	prisoners	under	observation	for	19	days.
20	,,	,,	,,	,,	36	,,
10	,,	,,	,,	,,	36	,,
10	,,	,,	,,	,,	14	,,
10	,,	,,	,,	,,	7	,,

Total 55 prisoners investigated over a period of 112 days.

Midnapore Jail.

20 prisoners under observation for 19 days.

Puri Jail.

16	prisoners	under	observation	for	18	days.
8	,,	,,	,,	,,	14	,,
10	,,	,,	,,	,,	7	,,
25	,,	,,	,,	,,	20	,,

The whole jail—about 200 prisoners—has been under observation since 1st January 1909, about six months.

The prisoners have been divided into two batches, and each batch has been kept on a diet based on the information gained from these investigations.

A report of the results obtained will be found further on.

Motihari Jail.

25 prisoners under observation for 16 days.

Buxar Jail.

20	prisoners	under	observation	for	52	days.
25	,,	,,	,,	,,	14	,,

Bhagalpur Jail.

20	prisoners	under	observation	for	7	days.
20	,,	,,	,,	,,	30	,,
5	,,	,,	,,	,,	14	,,

Ranchi Jail.

16 prisoners under observation for 14 days.

Darjeeling Jail.

13 prisoners under observation for					12 days.	
12	,,	,,	,,	,,	12	,,
12	,,	,,	,,	,,	10	,,

In the work of investigating the nutritive value of Bengal Jail dietaries we have had over 250 prisoners under observation for 350 days. During this time these prisoners were actually fed by us on a known diet, and their excreta collected for analysis.

4. Chemical analyses—

(*a*) Determinations of total nitrogen—1,950—which in addition to 300 in food analyses brings the total Kjeldahl's determinations to 2,250.

[Every determination was done in duplicate in the analyses of the excreta.]

This does not take into account a very large number of controls, nor the determinations of urea as nitrogen.

(*b*) The total chlorides were estimated in every specimen of urine and fæces that came under examination—the total estimations would therefore be half the number of Kjeldahl's determination, but to this must be added about 350 special salt-metabolism experiments, bringing the total up to about 1,500.

(*c*) The free ammonia of the urine has been estimated on about 200 different occasions.

(*d*) A large number of observations have been made on the amount of urea and its relationship to the total nitrogen. These determinations were carried out by the Mörner-Sjöqvist process as modified by Bödlker.

(*e*) The uric acid, purin bodies and phosphates have all come under observation during the investigation.

5. Blood examinations—

A large number of blood counts and hæmoglobin estimations have been done in connection with the effects of salt on the system. We have also made extensive enquiries as to the effects of large amounts of salt on body-weight, on the percentage of corpuscles in the blood, and on the percentage of chlorides in the serum; but, as the methods of accurately investigating the percentage of corpuscles requires much time and the use of an electric centrifugal

machine (which was not available in the different jails), no great amount of attention was given to this part of the work on prisoners ; a certain number of observations were, however, carried out in the Physiological Laboratory on the menial staff and on animals.

Methods of work.

6. A short account of our methods is necessary in order to give some indication of the extent of the investigations; and at the same time it will obviate any repetitions [in the account furnished of our results.

I. Analyses of Food-stuffs and Excreta.—The food materials in use in seven different jails in Bengal were analysed as regards their protein, carbohydrate, fat, moisture and ash. As will be seen from the tables of analyses, we were not content with a single analysis, but made repeated analyses of the same sample to obtain an average that would be, as far as possible, absolutely accurate. To ensure this we estimated the protein in at least six samples—often more—of the food-stuffs from the different jails, and never accepted any result that departed more than 0·5 per cent. from the average of the analyses closest to each other in amount. This we considered necessary as the food-materials are often contaminated and it is difficult to obtain samples absolutely pure—this remark applies particularly to the dals which are often mixed with one another. As will be seen, we were able to obtain results that are exceedingly close to each other, and may justly claim that the average percentages presented are, for the samples analysed, absolutely accurate.

The protein estimations were all carried out by the Kjeldahl process as modified by Bernard Dyer. A modification which we found of the greatest service was to add a few drops of a weak solution of phenolphthalein to the cross-tube leading from the distillation flask; as soon as the ammonia begins to come over this indicator becomes red and remains so until all the ammonia is distilled over, when the colour disappears. By using this simple method a great source of trouble in Kjeldahl's process is eliminated, *viz.*, a want of knowledge of the proper time to stop the distillation. It will be evident that to lay down any definite time, such as half-an-hour, as usually stated, is manifestly absurd: the time required will depend largely on the source of heat used in the distillation, and furthermore, we found that different samples of the same substance

often required different times for complete distillation of the ammonia. To state that the distillation should go on until a certain quantity of fluid had passed over—one of the rules given for guidance—is fallacious. We found that very varying quantities of fluid passed over in different distillations before all the ammonia was collected. It is, therefore, most important to be able to say definitely whether at the end of half-an-hour or at the end of an hour, and whether we have distilled over 300 c.c. or 500 c.c. of fluid—that we have obtained all the ammonia from the sample and collected it ready for titration. This we are in a position to do by using the simple method, here introduced and made use of by us in over 2,000 Kjeldahls with the most gratifying results. We have no hesitation in saying that 99 per cent. of the protein estimations made in these investigations, in which two or more samples of a urine or fæces were put up, the results obtained tallied within a decimal place of each other, and in a very large proportion absolutely identical results were obtained. We have found that with proper care and by keeping the conditions the same the most accurate results can be obtained. As a proof of this we were able to point out to a firm of manufacturing chemists that their so-called pure sulphuric acid contained a small percentage of nitrogen which they subsequently admitted to be the case. This we discovered from a comparison of the results of controls made with this acid and that formerly in use. Estimations of the nitrogen in weighed samples of pure urea gave similarly accurate results, when the distillation was stopped on the loss of the red colour of our indicator.

Estimation of the ammonia of the urine :—

I. The method followed in every instance was that described by Nencki and Zaleski in which the urine, after liberation of all free ammonia by the addition of lime water, is distilled *in vacuo* at a temperature not exceeding 50°C. Here again we found the addition of a few drops of our colour indicator of the greatest service in intimating when the ammonia began to come over, and when all was over. It simplified and shortened the whole process, besides affording trustworthy evidence that we had obtained the full amount possessed by the sample examined, and that our results were accurate.

The analyses and estimations of other constituents of the urine and fæces were done by the ordinary methods described in text-books and call for no comment from us.

The Carbohydrate of the food-stuffs analysed was estimated by completely changing all the carbohydrate material into sugar by the action of hydrochloric acid, and then estimating the percentage of sugar by Fehling's method, checking the results by the Pavy-Fehling method or the Picro-Saccharometer.

The Fat was estimated in the usual way by means of a slightly modified Soxhlet apparatus manufactured to our drawings by Messrs. Baird and Tatlock, London.

The moisture and ash require no comment.

II. The method of procedure when we came to investigations on prisoners was almost invariably to use as our unit a batch of five picked prisoners—in a few cases we had four in the batch, in some six and in some ten. The excreta from these five men—or from the batch—were pooled, and in every case two samples of the urine and two of the fæces—when examined—were put up for nitrogen, and a sample of each for chlorides; one of the urine for ammonia and sometimes the urea, phosphates, purin bodies, etc., of the urine were also estimated. The specific gravity and reaction of the urine was always taken. The weight of the prisoners making up the batch was taken every day; it was noticed that while individual prisoners varied in weight from day to day, the average weight of the batch after the first three or four days remained practically constant.

The prisoners to form the subjects of the investigations having been chosen, were isolated from the other prisoners. In the larger jails we were able to make use of a block of cells with a common yard where the work given to the prisoners could be carried out, and where they were able to get air and exercise while at the same time the facilities for feeding and collection of excreta were much greater than was the case in the smaller jails. In the smaller jails a large block of cells was not available for this purpose; we were always able however to obtain some godown or store for the isolation of the batches.

The next step was to put the batches on the diet that we wished to investigate. This was usually done for some days before any collection of the urine and fæces for analyses was made, in order to give time for the proper amount of protein to be absorbed and nitrogenous equilibrium to be established, and to allow of the usual increase in body-weight which we found to occur when the prisoners were first put on a diet weighed and distributed by us.

At every change of diet the same routine was observed, *i.e.*, the prisoners were kept on the diet two or more days before collection of their excreta for analyses.

III. The feeding of the prisoners was carried out on the following plan :—

The amount of each separate item of the diet was weighed dry before cooking, again weighed after cooking, and then distributed to each separate batch of prisoners under observation. Any cooked food that remained uneaten was weighed, and its amount in the dry form calculated and subtracted from the total dry material of the diet. The total value of the diet in proximate principles was then determined by analyses of the food materials actually in use at the time of the experiment.

IV. The collection of the excreta :—The pooled urine and pooled fæces of the prisoners forming the batch were collected, measured—or weighed as the case may be—and samples were taken as required. This was done usually for five days, sometimes more, for each set of observations.

In the investigations carried out in Calcutta, there was no difficulty as the excreta were sent to the laboratory every morning; but for jails hundreds of miles away from Calcutta we had to make special arrangements. The plan that we finally adopted and which gave very satisfactory results, was to have the urine and fæces measured or weighed, as the case be, on the spot and samples put up at once: for nitrogen with the usual amount of pure sulphuric acid; for ammonia with calcium hydrate; for urea with the barium hydrate and chlorate mixture, then the ether and alcohol solution was added: the fæces were weighed, thoroughly mixed and samples weighed and put up with sulphuric acid for nitrogen; or dried, weighed, and put up. By following this method we eliminated all source of loss of nitrogen from decomposition, and were able to make a week's collection before sending the samples to the labbratory. This was a matter of some importance for some of the jails dealt with were over 300 miles from Calcutta—one being 411 miles away.

The samples obtained in this way were collected in reagent bottles with ground-in glass stoppers; for safety, the stoppers were sealed and tied tightly in, and the bottles were packed in a partitioned box—a partition for each bottle—with saw-dust, and carefully guarded the whole way to the laboratory to prevent breakages. We had practically no breakages with these samples.

> In the Presidency Jail, Calcutta, Midnapore Jail and Puri Jail we estimated the total nitrogen of both urine and fæces. In the remaining jail we decided to rely on the total nitrogen of the urine for our results. Our reasons for so doing were that we found a good deal of difficulty in separating the fæces corresponding to the diet given, owing to the fluid character of the stools. It was also very difficult to deal with the large volume of fæces passed by the prisoners, and the unpleasant nature of the work was a serious source of objection to its being properly performed.

Our main reason, however, for giving up the fæces estimations and relying on the urine—thus following Chittenden's method—was that we found that, so long as the prisoners were healthy and taking their food properly, very similar results were obtained whether we worked with the fæces or the urine.

In order to make allowance for the nitrogen that had undergone metabolism in the body but was eliminated by the skin, or in the stools in the remains of the digestive juices and intestinal débris, we decided to add 0·5 gramme of nitrogen per man daily to the total nitrogen of the urine. This may be a little too low, but it does not affect the results to any appreciable extent.

As indicated above, we had to eliminate all source of error by examining only prisoners in good health and at once rejecting anyone who showed signs of sickness. On several occasions we have rejected a whole batch and the work done on it for this reason.

Another factor that we had to take into consideration was the gain or loss in body-weight. Although it is practically certain that, in a very large proportion of cases, a temporary gain in body-weight is not accompanied by a retention of nitrogen, but is due to retention of water or storing of fat, still we decided to reject all observations—in which the urine was relied on—when anything more than a trifling difference in the average weight of the batch existed between the first and last day of observation. As a matter of fact while there was, in every instance, a gain in weight as soon as the prisoners were placed on a weighed-out dietary, after the first few days the average weight of a batch remained practically constant.

In this connection the very large bulk of the stools passed and their average weight was a very marked feature; furthermore, it was noticed how very similar the percentage of nitrogen present in the mixed fæces of a batch was from day to day whatever the weight the stools happened to be, or whatever the diet given. This has been observed by other workers* and, without pressing the point, it was found that the percentage of nitrogen of the fæces was fairly uniform under different conditions, while the amount of total nitrogen varied largely with the total weight of the stools passed.

* Prausnitz, Zeitsch f. Biologie. 1897.

We have now traced the history of Bengal Jail dietaries as recorded in the excellent papers cited, and indicated the different factors that led up to the present investigation. We have given in brief outline an account of the scope of the present enquiry with some discussion on the difficulties to be overcome, and an indication of the way in which we have attempted to arrive at the nutritive value of jail dietaries and their modifications. We have discussed what the real value of a diet consists in, *viz.*, the amount of nitrogen it presents that is capable of absorption and assimilation, and the amount of energy it is able to furnish (deducting that lost to the body in the urine and fæces, and the important loss from excessive gastro-intestinal fermentation). We have given a short résumé of the present investigations carried out on the different races of people examined in the several jails of the province, with a description of ou methods of work.

Nothing now remains but to give an account of the results obtained with the conclusions at which we have arrived. In doing so we shall approach the subject as "independent enquirers seeking the truth unconcerned where the evidence may lead us, and shall endeavour to put all aspects of the question that come before us in an equally strong light."

Before proceeding to do this it is our pleasing duty to tender our best thanks for the kindness shown us, the interest taken in the work, and the able assistance in its fulfilment, invariably given us by those officers of the Jail Department in Bengal, with whom we have come in contact during the investigations.

The Inspector-General of Jails, Lieutenant-Colonel W. J. Buchanan, I.M.S., has earned our best thanks for smoothing the path and giving us a free hand to make use of the jails as we found necessary. To the Superintendent of the Presidency Jail, Calcutta,—Major Mulvany, I.M.S.—we gave much trouble by continually asking for prisoners, he never resented our doing so, but, on the contrary, was always willing to give us every assistance in his power. Captain Mackelvie, I.M.S., of the Puri Jail, has given us much help in our work in that jail, and kindly undertook to supervise the six months' experiment on the whole population of his jail. Captains Gillitt and Hamilton of the Behar Jails assisted us very ably in the work on the Behari—sometimes much to their own inconvenience. To Major Maddox, I.M.S., of Ranchi, we are specially indebted for information concerning the aboriginal tribes investigated in Ranchi Jail.

Lastly, we have to thank Mr. Piffard, Superintendent of Darjeeling Jail, for making things easy for us among the representatives of the more truculent tribes of the hills.

To Professor B. Moore of the Bio-Chemical Department of Liverpool University we owe a debt of gratitude for much advice regarding some of the more knotty points that turned up during the course of the investigations.

PART I.

CHAPTER I.

The Food-Stuffs of Bengal Jail Dietaries.

The food materials in use in the Bengal Jail dietaries are all derived from the vegetable kingdom ; so that, for the time during which they are under confinement, the prisoners are strict vegetarians. No animal food of any kind enters into their dietaries, except in hospital and in certain circumstances which will be referred to.

These food materials consist of rice, different dals and vegetables in Lower Bengal, and rice, wheat ata or makkai ata (maize), different dals (pulses) and vegetables in Behar. The rice in use is of two kinds—Burma rice and Country rice. Burma or Rangoon-rice, the so-called "white" rice, is prepared direct from the unhusked "paddy" ; it is milled by machinery and the husk together with the pericarp and surface layers of the seed is removed. The result is a clean white rice grain, deprived to some extent of its outer layers and therefore slightly also of its protein and mineral constituents.

Indian or Country rice is prepared by soaking the "paddy" for from twenty-four to forty-eight hours in water, then transferring it to lightly covered cylinders in which it is steamed for from five to ten minutes ; subsequently it is removed to open paved — usually sun-baked mud — courts and dried by exposure to the sun. It is either stored as "paddy" or milled at once.

The sample obtained by this process is of a yellowish-brown colour, usually very dirty from contamination with dust and earth acquired during the drying process. The outer layers of the grain are not lost so that, weight for weight, it should contains more protein than Rangoon or Burma rice.

Reference to our table of analyses of the food-stuffs will show that we did not find the country rice to contain a higher percentage of protein than Burma rice. This is probably due to the much greater contamination of the former with foreign material. Our analyses represent the composition of the food materials as received from the different jails, and as those materials are given to the prisoners. They were not put through any preparation such as drying, cleaning, etc., but were simply analysed as received. Rice forms by far the greater proportion of the ordinary jail diet. The following are the scales in general use in Bengal Jails :—

	In Lower Bengal.	In Behar.
Burma or Country rice	26 ozs	16 ozs.
Different dals	6 „	6 „
Vegetables	6 „	6 „
Wheat ata		10 „
or		or
Makkai ata		12 „

Rice is the poorest of all cereals in protein ; when cooked it swells up and absorbs about three and a half times its weight of water, some of its mineral constituents being dissolved and lost when the boiled rice is strained. Very little of the protein is removed when rice is boiled in a large quantity of water and the excess of water drained off—the ordinary method of cooking rice in Bengal jails. From analyses of the drained material there appeared to be a loss of about 0·20 per cent. protein.

The percentage of starch in rice is high, up to about 80 per cent. This starch is present in small and easily digested grains. Fat is very deficient in rice.

According to Continental authorities,* practically none of the starch of rice is lost from non-absorption, but the waste of protein amounts to about 20 per cent. These figures, however, were obtained from dietaries in which the quantity of rice given was only a few ounces—a very different thing from a diet containing twenty-six ounces, so far at least as absorption of protein is concerned.

The different dals in use in Bengal jails are :—

Mung, Gram, Mottar, Arhar, Massur and Kalai dals. They belong to the natural order Leguminoseae and are chiefly characterised by their richness in protein, being termed for this reason "the poor man's beef." The chief protein of pulses is legumin† which closely resembles casein of the milk in its composition. It is by the addition of dal to the diets in Bengal that their deficiency in protein is made up. The amount in the dietaries has undergone a gradual increase and is over six ounces per man daily.

As will be seen from our analyses the percentage of protein is uniformly high, but varies in the different kinds of dal in use—Mung and Massur containing up to 26 per cent., Mottar and Kalai somewhat less, and Arhar and Gram dal less still, in round numbers about 20 per cent. When cooked, dal in whatever form takes up a large amount of water, usually at least three times its own weight. This increase in water means a corresponding increase in bulk and must, therefore, be taken into account in considering the real nutritive value of this form of food. Investigations‡ on the absorption of pea or lentil flour, properly cooked, show that the protein is all taken up except about 8 or 9 per cent. If, however, the pulse is not given in a state of fine division, as when the lentils are simply boiled till they become more or less soft—the method of cooking in Bengal prisons—the loss of protein has been found to rise to 40 per cent.§ In Lower Bengal, rice, dal and vegetables make up the whole diet—the only variations possible being the ringing of the changes in the different kinds of dal.

We have already referred to the value of this diet as regards its digestibility and absorbability. We know that if the bulk of a vegetable food given be small

* Kumagawa, Virchow's Archiv, CXVI.

† A nucleo-albumin (Maly's Jahres-Bericht), see Hutchison, page 229.

‡ Strümpell, Deut. Archiv. f. klin, med. 1876.

§ Strümpell, *loc. cit.*

and the proportion of contained cellulose scanty, digestion is very complete and that under contrary conditions, low absorption is to be expected. Unfortunately the dietaries of Bengal jails are very bulky and contain a large amount of cellulose so that digestion and absorption is very imperfect: we have rarely found more than 55 per cent. of the protein of the ordinary jail diet absorbed when the full diet was consumed. This is in general agreement with the findings of other observers as the following table, compiled by Hutchison, shows :—

Relative absorption of the protein of various foods—

Diet.

	Protein not absorbed.
Meat	2·3 per cent.
Lentil flour	10·5 " "
Dried peas	17·0 " "
Beans	30·3 " "
Potatoes	32·0 " "
Lentils (soaked and boiled)	40·0 " "

The fact that in Bengal jail diets the absorption of protein is on an even lower scale than that given in the above list can be quite satisfactorily explained by the extreme bulkiness of the prisoners' full diet when cooked; as evidence of this we find that diminution in the bulk of the diet is at once accompanied by an increase in the percentage of protein absorbed.

One factor in the causation of this deficient absorption of protein, besides those already referred to, is that the presence of a large amount of starch in the intestines appears to be unfavourable to the absorption of protein.

Hutchison attributes this to the fermentation of part of the starch leading to the production of acids that unduly quicken the intestinal movements, and hurry the contents through the small bowel where absorption is most active, into the large bowel where absorption is at a minimum.

That active fermentation does take place on jail dietaries there is plenty of evidence to show, and there is no doubt that one reason why a diminution in the bulk of these diets is followed by an increased protein absorption, is that the excessive fermentation is lessened, and the intestinal contents are not so hurried on, more, relatively and actually, of the protein of the diminished diet being absorbed. According to Hutchison the total capacity of an ordinary sized European stomach is about 1,200 grammes and the weight of the ordinary cooked jail diet is at least 4,000 grammes, so that the stomach would be required to be filled to the extreme limits of its capacity three times a day in order to get through the total amount. Of course the habitual ingestion of these bulky diets leads to distension of the stomach and bowels with a consequent disproportionate abdominal development. This increase in the capacity of the stomach allows of more food being taken and also, when the bulk of the food is decreased, gives rise to the feeling,

for a time, of non-satisfaction and hunger. This, however, soon passes off when a more nutritious diet is prescribed, the stomach returning to something like its normal capacity and the feeling of emptiness disappearing.

The wheat ata or flour of the diets for Behari prisoners is prepared from the whole grain by prison labour by means of small grinding stones. If a grain of wheat be cut and examined microscopically, the following parts can be made out :—

1. The germ or embryo representing about 1·5 per cent. of the whole grain.
2. The kernel or endosperm consisting of two large masses of nutritive material. It makes up 85 per cent. of the grain.
3. The bran—an outer envelope composed mainly of cellulose impregnated with mineral matter. It forms about 13·5 per cent. of the grain.

In the method of stone grinding the bran is removed, the meal or flour consisting of the products of the germ and endosperm together. The exclusion of the bran from the flour entails a loss of mineral matter and some protein from the inner or aleurone cells.

This flour is baked into "chuppaties" of different sizes five ounces of wheat ata providing about six and a half ounces of "chuppaties." The "chuppatie" is non-aërated and is somewhat of the appearance of a thick pancake.

The chemical analyses of the wheat sent from the different jails show greater variation than any other of the food materials. This was largely due to the varying amount of moisture and to the amount of contamination present ; some of the samples were coarse, dirty and badly cleaned, and naturally gave low results. It is quite probable, however, that wheat grown in different districts shows variation in chemical composition. This is a side of the question which we did not investigate ; neither did we seek to distinguish between the different sorts of wheat grown in Bengal and Behar.

In wheat we get the closest approach in the percentage of its proximate principles to the ratio of nitrogen to carbon essential for a suitable diet.

Further, the fact that it does not when cooked absorb a high percentage of moisture enhances its value compared with other cereals and particularly with rice. It would, therefore, appear probable that large quantities of "chuppaties" could be consumed without danger of their bulk interfering with absorption. This may be true if they were given alone or with a concentrated form of food such as meat, fish, etc., but it does not hold good for the combination exemplified in the dietaries of Behar jails.

We found that, combined with constant quantities of rice, dal and vegetables, up to about ten ounces of wheat ata per man daily the absorption was at a maximum ; beyond this amount a diminution in the amount of protein undergoing metabolism took place. Whether this would be the case if the wheat ata were baked and aërated by European methods we are not prepared to say ; but there

can be no doubt that the tough, tenacious "chuppatie" is less easily penetrated by the digestive juices than is the lighter, aërated bread of Europeans. When chuppaties are given in fairly large amount with large quantities of rice, dal and vegetables there is much waste, and our results show a *percentage absorption* of protein in the Beharis very little better than is found in prisoners in Lower Bengal where wheat forms no part of the diet. Of course the Behari dietaries contain a very much larger quantity of protein than Lower Bengal diets, so that the actual amount of protein undergoing metabolism per man daily is greater.

Makkai—Indian corn or Maize ground to flour—forms part of the diet of Beharis during some seasons of the year. Twelve ounces replace ten ounces of wheat ata, when makkai is available, in the ordinary jail dietary. It is prepared in the same manner as wheat ata and is similarly baked in the form of small, very thick, masses with little cohesion. Our investigations show that its protein is quite as well absorbed but it does not contain so high a percentage of protein as wheat. It is not liked nearly so well by the prisoners; they complain that it gives them a sensation of weight in the stomach and heart-burn. In Darjeeling jail makkai is given in the form of porridge, which looks much more digestible than the hard, gritty masses of the Beharis' diet. The results, however, are not very dissimilar although to some extent in favour of the Darjeeling method of cooking.

The ordinary vegetables in season are used in the jails. Each jail has usually a well-managed vegetable garden so that good vegetables are nearly always to be had.

We made no variation in the amount of vegetables sanctioned—six ounces per man daily—we accepted this scale as quite sufficient.

The following tables give the percentage composition in proximate principles of the samples of food-stuffs received from the different jails.

Special attention was paid to the question of the amounts of protein present—the most careful precautions being taken to obtain accurate results for the samples analysed. The analyses made from the same sample gave practically identical results.

In Table G we have given the average composition of all the different food materials obtained from the several jails of Bengal, with their heat value in calories per ounce calculated from the percentage composition of the proximate principles, and also as obtained by actual determination from the food-stuffs. The calculated heat value will be seen to be somewhat lower than the heat value determined by Professor Benedict from samples sent from India.

This is what would be expected; we have calculated the heat value on the percentages of the protein, carbohydrate and fat present, taking no notice of non-digestible material, whereas the experimental method gives the total heat value for everything combustible in the sample.

The calculated heat value, therefore, gives the net amount available to the economy after absorption, while the determined heat value gives the gross amount available in the sample.

It will be evident how very closely the figures obtained by the experimental method and by calculation correspond to each other when due allowance is made for the presence of non-digestible combustible material as cellulose, woody-fibre, chitinous coverings, etc., and for the difference in the percentage of moisture present in the samples analysed by us and those examined by Professor Benedict in America. We give the necessary information in a note appended to Table G, and, at the same time, we desire to express our best thanks for the valuable assistance Professor Benedict has given us and also for much kindly advice.

Chemical Analysis of Food Stuffs of Bengal Jails.

TABLE A.

I. Presidency Jail, Calcutta.

Food-stuff.	Proximate principle.	Number of analyses carried out						Moisture per cent.	Ash per cent.	Average percentage Composition.
		1	2	3	4	5	6			
Burma Rice—										
Sample (1)	Protein	6·76	6·88	6·71	6·82	6·97	6·81	11·13	1·34	6·8
	Carbohydrate		average		..	..	..	..	..	77·2
	Fat	·99	·96	·98	..	..	..	..	.	0·9
Sample (2)	Protein	7·18	7·16	7·06	7·04	6·96	7·00	..	..	7·0
	Carbohydrate		average		..	..	..	..	..	77·2
	Fat	·94	·96		..	..	..	..	.	·9
Country Rice (old)—										
Sample (1)	Protein	6·35	6·25	6·30	6·31	6·35	6·32	10·73	1·18	6·3
	Carbohydrate		average		..	..	..	..	..	78·8
	Fat	·83	·90	..	..	..	..	..	..	0·8
Sample (2)	Protein	6·71	6·87	6·75	6·68	6·82	..	..	..	6·7
	Carbohydrate	..	..	..	..	..	..	..	..	..
	Fat	..	..	..	..	..	..	..	..	..
Wheat ata or Flour	Protein	13·25	13·31	13·66	13·68	13·45	13·51	10·86	2·23	13·4
	Carbohydrate		average		..	..	..	..	..	67·4
	Fat	2·44	2·42	2·44	..	..	..	..	..	2·4
Massur Dal	Protein	25·12	25·48	25·26	25·55	25·43	25·58	10·0	3·23	25·4
	Carbohydrate	54·3	53·8	55·0	..	..	..	..	..	54·3
	Fat	2·66	2·64	..	..	..	..	..	..	2·6

TABLE A—*contd.*

I.—Presidency Jail, Calcutta.

Food-stuff.	Proximate principle.	Number of analyses carried out. 1	2	3	4	5	6	Moisture per cent.	Ash per cent.	Average percentage Composition.
Mung Dal	Protein	23·98	23·87	24·12	24·18	23·82	23·88	10·54	3·86	23·9
	Carbohydrate	52·7	53·8	52·4	..	..	..	..	..	52·9
	Fat	3·55	3·87	..	..	..	..	..	..	3·7
Gram Dal	Protein	19·35	19·43	19·46	19·81	19·46	19·73	9·97	3·82	19·5
	Carbohydrate	49·8	49·03	48·4	..	..	..	..	..	49·0
	Fat	4·3	4·5	..	..	..	..	..	..	4·4
Arhar Dal	Protein	21·50	21·59	21·37	21·43	21·33	21·38	9·66	5·23	21·4
	Carbohydrate	54·30	54·60	54·80	..	..	..	..	..	54·5
	Fat	3·60	3·55	..	..	..	..	..	..	3·5
Mattar Dal	Protein	21·56	21·78	21·68	21·56	21·68	21·68	..	..	21·6
	Carbohydrate	52·80	53·30	52·87	..	..	..	..	..	52·9
	Fat	1·99	2·04	..	..	..	..	..	..	2·0

TABLE B.

II.—Midnapore Jail.

Food-stuff.	Proximate principle.	Number of analyses carried out 1	2	3	4	5	6	Moisture per cent.	Ash per cent.	Average percentage Composition.
Rice (Coarse, Country, Balasore)	Protein	6·80	6·93	6·81	6·62	6·98	6·68	9·45	·96	6·8
	Carbohydrate	..	average	..	..	..	..	..	..	78·8
	Fat	·83	·91	..	..	..	..	..	..	0·8
Massur Dal	Protein	25·68	25·52	25·46	25·49	25·51	25·54	9·80	2·61	25·5
	Carbohydrate	54·2	54·4	54·6	..	..	..	..	..	54·4
	Fat	3·13	3·45	..	..	..	..	..	..	3·2
Mung Dal "Green Variety"	Protein	23·46	23·25	23·56	23·37	23·50	23·46	11·29	4·06	23·4
	Carbohydrate	53·80	53·20	53·95	54·01	..	..	..	..	53·7
	Fat	2·17	2·08	..	..	..	..	..	..	2·1
Gram Dal	Protein	20·23	20·31	20·33	20·75	20·31	20·50	9·73	3·78	20·4
	Carbohydrate	50·29	50·00	50·70	..	..	..	..	..	50·2
	Fat	4·05	4·02	..	..	..	..	..	..	4·0

TABLE B—*contd.*

II.—Midnapore Jail.

Food-stuff.	Proximate principle.	Number of analyses carried out. 1	2	3	4	5	6	Moisture per cent.	Ash per cent.	Average percentage Composition.
Kalai Dal (Beiri) . .	Protein . . .	22·20	22·22	22·21	22·35	22·18	22·32	10·73	3·76	22·2 .
	Carbohydrate. .	57·40	58·06	57·80	..	..	..	..	..	57·7
	Fat . . .	1·02	1·10	..	..	..	..	..	..	1·0
Wheat ata or Flour .	Protein . . .	12·35	12·31	12·08	12·35	12·06	12·13	13·61	2·41	12·2
	Carbohydrate. .		average		..	..	..	..	..	68·5
	Fat . . .	2·22	2·42	2·38	..	..	..	..	..	2·3

TABLE C.

III.—Motihari Jail.

Food-stuff.	Proximate principle.	Number of analyses carried out. 1	2	3	4	5	6	Moisture per cent.	Ash per cent.	Average percentage Composition.
Rice (Country)	Protein . .	6·86	6·70	6·56	6·42	6·70	6·76	10·78	1·03	6·6
	Carbohydrate .		average	..	..	..	..	..	..	78·8
	Fat . . .	·80	1·03	·90	..	..	..	..	..	0·9
Wheat ata or Flour (Coarse), badly cleaned	Protein . .	12·25	12·37	11·85	12·70	11·72	11·56	10·83	2·23	12·0
	Carbohydrate .		average		..	..	..	..	..	68·5
	Fat . . .	1·90	2·10	1·90	..	..	..	..	..	1·9
Massur Dal .	Protein . .	25·69	25·50	25·03	25·12	25·30	25·23	9·37	3·69	25·3
	Carbohydrate .	55·9	55·4	55·8	..	..	..	..	..	55·7
	Fat . . .	2·9	2·7	2·2	..	..	..	..	..	2·6
Arhar Dal .	Protein . .	21·50	21·80	21·40	21·42	21·68	21·87	..	..	21·6
	Carbohydrate .	54·0	53·8	54·2	..	..	..	..	..	54·0
	Fat . . .	3·30	3·32	3·20	..	..	..	..	..	3·2
Gram Dal .	Protein . .	19·30	19·18	19·21	19·18	19·50	19·65	..	..	19·3
	Carbohydrate .	51·80	52·10	51·80	..	..	..	..	..	51·9
	Fat . . .	4·20	3·90	3·80	..	..	..	..	..	3·9
Makkai ata or Flour . .	Protein . .	9·60	9·81	9·68	9·75	9·78	9·87	11·25	2·39	9·7
	Carbohydrate .		average		..	..	..	..	..	66·2
	Fat . . .	..	..	..	..	..	..	..	..	..

TABLE D.

IV.—Puri Jail.

Food-stuff.	Proximate principle.	Number of analyses carried out 1	2	3	4	5	6	Moisture per cent.	Ash per cent.	Average percentage Composition.
Rice (new Balasore)	Protein	6·87	7·03	7·00	6·92	..	..	11·86	1·59	6·9
	Carbohydrate		average	..	..	..	..	..	..	78·8
	Fat	·83	·81	..	..	..	..	..	..	0·8
Rice (old)	Protein	6·75	6·75	6·87	..	..	..	11·34	1·46	6·7
	Carbohydrate		average		..	..	..	..	..	78·8
	Fat	·77	·79	..	..	..	..	..	..	0·7
Wheat ata or Flour	Protein	10·93	11·00	10·87	..	..	..	12·52	2·14	10·9
	Carbohydrate		average		..	..	..	..	..	69·5
	Fat	1·80	2·20	..	..	..	..	..	..	2·0
Kalai Dal	Protein	24·51	24·68	24·23	..	..	..	10·67	3·58	24·4
	Carbohydrate	58·30	57·90	..	..	..	..	..	..	58·1
	Fat	1·03	·91	..	..	..	..	..	..	0·9
Mung Dal	Protein	23·36	23·46	23·56	..	..	..	10·79	2·79	23·4
	Carbohydrate	53·30	54·03	..	..	..	..	..	..	53·6
	Fat	2·20	2·30	..	..	..	..	..	..	2·2
Gram Dal	Protein	20·50	20·43	20·26	..	..	..	10·19	3·60	20·3
	Carbohydrate	52·60	52·70	..	..	..	..	..	..	52·6
	Fat	4·50	4·90	..	..	..	..	..	..	4·7
Arhar Dal	Protein	23·62	23·75	23·43	..	..	..	10·65	4·64	23·6
	Carbohydrate	54·40	54·60	..	..	..	..	..	..	54·5
	Fat	1·29	1·53	..	..	..	..	..	..	1·4
Massur Dal	Protein	25·37	25·50	25·31	..	..	..	10·71	3·58	25·3
	Carbohydrate	55·50	55·50	..	..	..	..	..	..	55·5
	Fat	3·10	2·90	..	..	..	..	..	..	3·0
Massur Dal (Dehusked and cleaned)	Protein	26·10	25·93	..	..	..	..	..	..	26·0
	Carbohydrate	..	..	..	..	..	..	..	..	..
	Fat	..	..	..	..	..	..	..	..	..
Mung Dal (Husked and cleaned)	Protein	28·50	28·37	28·37	28·51	28·50	..	9·99	..	28·4
	Carbohydrate	..	..	..	..	..	..	..	..	..
	Fat	..	..	..	..	..	..	..	..	..
Mottar Dal (another sample)	Protein	24·06	23·93	24·12	..	..	..	..	..	24·0
	Carbohydrate	..	..	..	..	..	..	..	..	..
	Fat	..	..	..	..	..	..	..	..	..

TABLE E.

V.—BHAGALPUR JAIL.

Food-stuff.	Proximate principle.	Number of analyses carried out. 1	2	3	4	5	6	Moisture per cent.	Ash per cent.	Average percentage Composition.
Rice (new)	Protein	6·88	7·06	7·06	6·94	6·82	..	11·82	1·76	6·9
	Carbohydrate	..	average	..	..	..	..	..	..	78·8
	Fat	·91	·91	..	..	..	..	..	..	·9
Rice (old)	Protein	6·93	6·93	6·98	..	..	..	11·35	1·35	6·9
	Carbohydrate	..	average	..	..	..	..	..	..	78·8
	Fat	·90	·90	..	..	..	..	..	..	0·9
Massur Dal	Protein	25·80	25·51	25·56	..	..	..	11·26	3·56	25·6
	Carbohydrate	55·09	55·00	55·50	..	..	..	..	..	55·1
	Fat	3·30	3·70	..	..	..	..	..	..	3·5
Kalai Dal	Protein	21·03	21·02	21·10	..	..	..	11·21	3·48	21·0
	Carbohydrate	58·30	58·08	58·30	..	..	..	..	..	58·2
	Fat	1·03	1·50	..	..	..	..	..	..	1·2
Mattar Dal	Protein	22·56	22·21	22·31	..	..	..	10·96	3·60	22·9
	Carbohydrate	54·80	54·90	55·20	..	..	..	..	..	54·9
	Fat	1·70	2·06	1·94	..	..	..	..	..	1·9
Makkai ata or Flour	Protein	9·18	9·18	9·19	9·04	9·33	..	11·75	4·70	9·1
	Carbohydrate	..	average	..	..	..	..	..	..	66·2
	Fat	2·10	2·50	..	..	..	..	..	..	2·3
Wheat ata or Flour	Protein	9·75	9·71	9·47	Coarse, badly cleaned.	..	..	12·00	2·76	9·6
	Carbohydrate	..	..	..		..	..	..	..	..
	Fat	..	..	..		..	..	..	..	..
Flour (Different Sample)	Protein	12·38	12·35	12·26	Cleaner and purer wheat.	..	..	..	..	12·3
	Carbohydrate	..	..	..		..	..	..	..	..
	Fat	..	..	..		..	..	..	..	..
Arhar Dal	Protein	22·01	22·32	22·15	..	..	..	9·93	6·60	22·1
	Carbohydrate	54·80	54·90	53·1	..	..	..	..	..	54·2
	Fat	3·12	3·22	..	..	..	..	..	..	3·1
Gram Dal	Protein	20·12	20·25	19·86	..	..	..	10·33	3·67	20·0
	Carbohydrate	51·02	52·30	52·09	..	..	..	..	..	51·8
	Fat	4·80	4·10	..	..	..	..	..	..	4·4
Arhar Dal (another sample)	Protein	21·83	22·00	22·08	..	..	..	..	..	21·9
	Carbohydrate	..	..	..	..	..	..	..	..	..
	Fat	..	..	..	..	..	..	..	..	..

TABLE F.

Average Percentage Composition of Food Stuff in use in the Different Jails Examined.

Jail.	Proximate principle.	Burma Rice.	Country Rice (new.)	Country Rice (old).	Wheat ata.	Massur Dal.	Mung Dal.	Gram Dal.	Arhar Dal.	Mattar Dal.	Kalai Dal.	Makkai ata.
Presidency Jail, Calcutta	Protein	6·95	6·76	6·31	13·47	25·40	23·97	19·54	21·43	21·66	..	..
	Carbohydrate	77·25	78·85	78·85	67·40	54·36	52·96	49·07	54·56	52·99	..	..
	Fat	0·96	0·86	..	2·43	2·65	3·71	4·40	3·57	2·02	..	..
*Midnapore Jail	Protein	..	6·80	..	12·21	25·53	23·43	20·40	..	..	22·24	..
	Carbohydrate	..	78·85	..	68·52	54·40	53·72	50·26	..	..	57·75	..
	Fat	..	0·87	..	2·34	3·29	2·12	4·03	..	..	1·06	..
Puri Jail	Protein	..	6·94	6·79	10·93	25·39	23·46	20·36	23·60	..	24·47	..
	Carbohydrate	..	..	..	69·50	55·50	53·66	52·65	54·50	..	58·10	..
	Fat	..	0·82	0·78	2·00	3·00	2·25	4·70	1·41	..	0·97	..
Motihari Jail	Protein	..	..	6·66	12·07	25·31	..	19·33	21·61	..	..	9·75
	Carbohydrate	..	..	78·85	68·52	55·70	..	51·90	54·00	..	..	66·20
	Fat	..	..	0·91	1·96	2·60	..	3·96	3·27	..	..	..
Bhagulpur Jail	Protein	..	6·95	6·95	12·33	25·65	..	20·07	21·97	22·36	21·05	9·18
	Carbohydrate	..	78·85	78·85	..	55·19	..	51·80	54·26	54·96	58·22	66·20
	Fat	..	0·91	0·90	..	3·50	..	4·45	3·16	1·90	1·26	2·30
Buxar Jail	Protein	..	..	..	12·44	25·57	..	..	..	..	..	9·74

The low result for the protein of wheat ata of Puri Jail is partly due to the high percentage of moisture and partly due to dirt.
*The high results obtained in the analyses of Arhar and Kalai Dals were due to their contamination with Massur and Mung Dals

TABLE G.

Average Composition of Food Materials Examined.

	Protein.	Carbo-hydrate.	Fat.	Moisture.	Ash.	Heat value per oz. calculated. Calories.	Heat value per oz. obtained by experiment. * Calories.
Burma Rice	6·95	77·25	0·96	11·13	1·34	100·47	108·32
Country Rice	6·86	78·85	0·86	11·05	1·32	101·95	108 44
Wheat ata	12·24	70·92	2·18	11·83	2·43	102·44	114·34
Makkai ata	9·55	66·20	2·30	11·50	3·55	93·86	115·05
Mung Dal	23·62	53·45	2·69	10·87	3·57	96·69	114·88
Massur Dal	25·47	55·03	3·00	10·23	3·33	101·42	115·14
Gram Dal	19·94	51·13	4·31	10·07	3·72	93·95	111·52
Kalai Dal	22·58	58·02	1·10	10·87	3·61	96·58	114·57
Mattar Dal	22·01	53·97	1·96	10·96	3·60	93·47	114·40
Arhar Dal	21·67	54·27	3·33	10·08	5·50	98·04	117·86

* We are indebted to Professor Benedict of the Carnegie Institute, Washington, U.S.A., for these figures estimated by the calorimetric bomb from samples sent to him from India. The samples of the different food materials sent to Professor Benedict were obtained from the old crop and were in a dryer condition than when analysed by us as the figures in the table on next page show.

Heat of combustion of food stuffs.

Indian Grains.	Moisture of samples sent to America.	Moisture of samples analysed in India.	Heat of Combustion Calories per gram.
Burma Rice	9·77	11·13	3·820
Country Rice	10·66	11·05	3·824
Wheat Ata	10·17	11·83	4·017
Makkai Ata	9·97	11·50	4·094
Mung Dal	9·80	10·87	4·051
Massur Dal	9·92	10·23	4·059
Gram Dal	9·16	10·07	4·285
Kalai Dal	10·19	10·87	4·038
Mattar Dal	9·76	10·96	4·075
Arhar Dal	8·99	10·08	4·083

CHAPTER II.

The Nutritive Value of Bengal Jail Dietaries.

"We live not upon what we eat, but upon what we digest."

The chief uses of food are :— first, to form the tissues of the body and repair the waste of every-day wear and tear; secondly, to furnish energy for the muscular and other work that the body has to perform and to yield heat to keep the body temperature at a proper constant level.

We have already seen that a diet may be considered from two points of view, *viz.*: its power or capability of forming new tissues or repairing waste—this depends principally on its assimilable or available nitrogenous material; its power of yielding energy and heat—this is a function of the protein, carbohydrate and fat of the diet.

The real nutritive value of a diet depends not simply on the proportions of nutrients which it contains, but on the amount of those nutrients which can be made available to the body by digestion for the building-up and repair of the tissues and for the yielding up of energy. Therefore, in the study of a diet it will be sufficient—so far as its nutritive value is concerned—to estimate the amount of nitrogenous material that undergoes metabolism in the body and compare this with the quantity offered in the diet, and then estimate the potential energy available in the food compared with the energy given off by the body as heat or mechanical work. With regard to the amount of energy transformed in the body on the jail diets under investigation, we have no experimental evidence to produce, and shall, therefore, have to rely on the generally accepted standards of the requirements of the body for fuel, contrasting these standards with the amount of energy available in the dietaries.

The first and more important part of the problem we shall now take up, giving as concisely as possible the results obtained from investigations on prisoners on the ordinary jail dietaries and on modifications of those dietaries.

In order to render the work done on the nitrogenous metabolism of prisoners intelligible we shall follow the following scheme in stating our results :—

Scheme of work.

A	B
Bengali Diet.	Behari diets.

SECTION 1.

Value of diets in proximate principles.	Value of diets in proximate principles.

SECTION 2.

Amount of nitrogen undergoing metabolism in the ordinary jail diet, in the case of —

(*a*) Bengalis
(*b*) Ooriyas
(*c*) Aborigines (Ranchi plateau)

Amounts of nitrogen undergoing metabolism in the ordinary jail diets, in the case of—

(*a*) Beharis { Buxar. Bhagulpore.
(*b*) Hill tribes of Darjeeling.

SECTION 3.

Effects of varying the quantities of the components of the ordinary jail diets on nitrogenous metabolism.

(The curves of nitrogen-absorption under different conditions)

Effects of varying the quantities of the components of the ordinary jail diets on nitrogenous metabolism.

(The curves of nitrogen-absorption under different conditions.)

SECTION 4.

Effects of varying the components of the diet, *i.e.*, of adding wheat ata, fish or meat.

Effects of varying the components of the diets, *i.e.*, adding meat to the diet.

SECTION 5.

(*a*) Relative value of Burma and Country rice.
(*b*) Relative value of the different dals in use.
(*c*) Relative value of wheat ata and makkai ata.

SECTION 6.

Discussion of results and conclusions arrived at.

A—BENGALI DIET.

The ordinary jail diet of Bengal—leaving aside slight variations for undertrial prisoners up to one month and after one month—consists of :—

						Grammes.
Burma or Country rice	13 chittacks	=	26·65 ozs.	=		755·80
Different dals in use	3 ,,	=	6·15 ,,	=		174·41
Vegetables in season	3 ,,	=	6·15 ,,	=		174·41
Mustard oil	$\frac{5}{16}$,,	=	·64 ,,	=		18·14
Condiments	$\frac{1}{8}$,,	=	·26 ,,	=		7·37
Antiscorbutic	$\frac{1}{8}$,,	=	·26 ,,	=		7·37
Salt	$\frac{7}{16}$,,	=	·90 ,,	=		25·52

(One chittack is equal to 2·05 ozs. avoirdupois).

This is the ordinary diet scale in use for the great majority of the prisoners in both the large central jails and the district jails of Lower Bengal. Other scales are sanctioned in which the rice is diminished by 4 ozs., its place being taken by 3·4 ozs. of wheat ata or a like amount of Suttoo (fried gram dal ground to meal) but, so far as we are aware, the diet given above is the only one in general use.

SECTION 1.

1. The Value of this Diet in Proximate Principles.

TABLE I.

Food-stuff.	Rice.	Dals.	Vegetables.	Mustard Oil.	Condiments.	Anti-scorbutic.	Total in Grammes.
Protein	51·63	39·32	2·36	..	..	..	93·31
Carbohydrate	589·55	94·72	9·06	..	..	..	693·33
Fat	6·80	4·76	1·58	17·35	..	..	30·49

This calculation is based on the average figures given on Table G, Chapter I. The mean of the percentage composition of all the different dals is used in working out their value in proximate principles. Usually three or more dals are in use at the same time, being given in the diet alternately.

We may, therefore, accept the figures given in Table I as representing the average value of the diets in use in the jails of Lower Bengal, Orissa and Chota Nagpur. The value from day to day varies slightly above and below these figures according to the particular dals issued in the diet and the vegetables in season.

The apparent value of this diet.

We might hark back to Lewis' article again and quote his remarks on this subject :— "Taken as a whole, the nutritive value of this dietary not only exceeds under every heading, the "adapted" scale, which has been prepared from English Prison scales, but in most cases the amount of food actually issued is more than is given as a maximum dietary in either the Convict or Local Prisons of England and Wales. Computed on the English standard the scale should suffice for men weighing considerably more than the average weight of natives of Bengal." With this opinion we are in entire agreement; there is not the slightest doubt but that it is a most liberal diet both in nitrogenous material and in its potential energy

or caloric value. Calculated according to the accepted heat equivalents its fuel value is 3,508 calories, which is higher than that of any of the standard diets that have been formulated for Europeans and over 1,000 calories higher than is furnished by Ranke's diet.

As we shall have reason to see later, there are two great defects in this diet which lessen its nutritive value to a very serious extent, with the result that, while according to its chemical composition it seems to be superior to English Prison scales and even to some of the standard dietaries, it is really very much inferior. These defects are :—

(*i*) In order to obtain a diet offering 93 grammes of protein derived from rice and dal the bulk is so great that digestion and absorption are interfered with, so that a protein metabolism much below the normal takes place, compared with what would be the case with a European type of diet offering 93 grammes of protein.

The amount of protein is therefore deceptive and its real nutritive value is little more than that of 60 to 65 grammes of protein when offered in the form of diet given in European jails.

(*ii*) The large carbohydrate element is worse than useless. By its mere presence in the intestinal canal it hinders the absorption of protein: on account of the fermentative processes that are quickly set up, acid bodies are formed which increase peristalsis and hurry the food through the small intestine past the area most favourable for absorption. Further, the excessive fermentation and putrefaction, rendered possible by the large residue, leads to flatulency, dyspepsia, auto-intoxication and a tendency to intestinal disorders, diarrhœa and dysentery. The excessive carbohydrate element of the dietary is the source of the very high heat value, a value far higher than what would be considered necessary for a European living in a much colder climate, where fuel for the production of heat is a much greater necessity than in India. Further, the average amount of work done by the native worker in prison—or outside, for that matter— calls for comparatively much less fuel in the food to supply the necessary energy. So that, neither for the production of heat nor as a source of energy for work is there any large demand for carbohydrate, yet we find this element present in an amount out of all proportion to what would be considered sufficient for a European of a similar body-weight doing three times as much work and living in a very much colder climate.

Now fuel supplied and made use of in the system can only leave the body in the form of heat and mechanical work, so that the Bengali prisoners if they were able

to make use of the 3,500 calories of their dietary must either produce a large amount of heat—requiring great radiation, conduction, etc., to keep the body temperature normal—or require really hard labour to dissipate the caloric value as mechanical energy. There is little doubt that neither of these conditions obtains— neither as a source of body heat nor as a source for the energy of muscular contraction is the large fuel value of their dietaries worked off.

The question, therefore, arises—what becomes of the great potential energy offered in these dietaries ? The answer to this would appear to be three-fold : a part of the carbohydrate, varying in amount according to the needs of the body, is absorbed—so long as the processes going on in the intestinal canal are physiological—and made use of to supply body heat and energy for muscular contraction ; a part undergoes little or no change in the bowel and passes out undissolved and very much in the same form as when ingested—this is probably due to its being bound up with cellulose, so that the digestive juices are unable to penetrate to the starch granules and set up the changes essential for absorption ; a third part is broken up in the digestive tract by excessive fermentation, which beginning in the stomach is continued in the intestines. In this way a very large percentage of the total potential energy of the diet may be dissipated through the conversion of its starch or sugar into carbon dioxide, methane, hydrogen, acetic acid, lactic acid, butyric acid, etc., and other fermentative products of low caloric value.

Besides this loss of the potential caloric value there is a considerable amount of evidence to show that excessive fermentation leads to a simultaneously disturbed digestion of protein, so that a vicious circle becomes established. It is highly probable that the excess of acid products is capable of setting up catarrhal inflammation of the small intestine and of inflicting injury on its delicate epithelial lining ; and there is little doubt but that many cases of chronic gastritis are dependent on excessive fermentative activity in the stomach. It is not, therefore, to be wondered at that, with these results of excessive fermentation, absorption of protein and carbohydrate should alike suffer and signs of mal-nutrition become evident. The practical evidence of the truth of these deductions is to be found in the extreme prevalence of bowel complaints in Bengal, the presence of oxaluria, hyperchlorhydria, toxaemia, increased acidity of the urine, abdominal distension, acid in the fæces, etc.

If further evidence were required that by excessive carbohydrate fermentation loss to the body of a very large proportion of the potential energy of the diet takes place, it is afforded by the practical absence of any marked tendency to the storing of fat amongst the working population of Bengal.

We may conclude, therefore, that the carbohydrate element in the quantities presented in Bengal Jail dietaries is not only useless and wasteful but actually

harmful. While agreeing, therefore, with Lewis's opinion on the dietary we condemn it for a totally different reason; whilst believing that the diet is excessive for prisoners of the body-weight of the Bengali, and agreeing that it offers more nitrogen and energy per kilo of body weight than that found necessary in English prisons, we condemn it because, on account of its bulk and composition, much less than the proper proportions of its nutrients can be absorbed and made use of in the system. We shall show, with regard to the most important element—protein—that the level of nitrogenous metabolism attained on such a diet is exceedingly low—very much lower than that of prisoners in English prisons. The diet is excessive, not because it entails too high a level of nitrogenous metabolism, but for exactly the opposite reason.

SECTION 2.

2. The amount of nitrogen undergoing metabolism on the ordinary jail diet.

Having worked out the chemical value of the average diet to be about 93 grammes of protein, the next step was to investigate how much of that quantity was absorbed from the food given.

This was done for the Bengalis, Ooriyas and aborigines of Chota Nagpur. The work was carried out in the Presidency Jail, Calcutta, Puri Jail and Ranchi Jail. These three centres fairly well cover the different classes of Lower Bengal who are on this type of dietary.

(*a*).—THE PRESIDENCY JAIL, CALCUTTA.

In this jail Burma rice was used entirely, to the exclusion of country rice. One effect of this comes out very plainly in all the investigations in which the whole twenty-six ounces of Burma rice was given in the diet, *viz.*, that it was found practically impossible to get the prisoners to consume the full diet for more than a day or two. The result of this was, that in the Presidency Jail we have not been able to obtain a complete series of observations on prisoners showing the amount of nitrogen undergoing metabolism on the whole diet. We have, however, a number of observations carried out when the greater part of the Burma rice was consumed. From an average of these it will be possible to show the ordinary amount of nitrogenous metabolism that takes place on the full jail diet with Burma rice. No observations are included in this series in which less than 4½ ozs. of Burma rice per day was the average amount consumed.

TABLE II.

Investigation to determine the degree of nitrogenous metabolism on a diet composed of (practically) the full quantities of the jail scale.

(i) Ten prisoners on the full diet of Burma rice and arhar dal observed for two consecutive days.

MIXED BATCHES.	Urine quantity.	Re-action.	Total N. of urine.	N. of Burma rice.	N. of arhar dal.	N. of vege-tables.	Weight.
	C. C.		Grms.	Grms.	Grms.	Grms.	Lbs.
Three Hindus . .	18,000	Acid	72·34	81·40	60·20	4·72	116·4
Seven Mahomedans .	21,790	„	74·71	81·40	60·20	4·72	116·4

Total intake of nitrogen—
- N. of Burma rice . . 162·80 grms.
- N. of arhar dal . . 120·40 „
- N. of vegetables . . 9·44 „

Total . =292·64 „

Total output of nitrogen—
- N. of urine . . . 147·05 grms.
- ·5 grm. N. per day constant per man 10·00 „

Total N. metabolism . . =157·05 „
= 53·66 per cent. of the total N. of the diet
= 7·85 grms. N. per man daily.

(ii) Ten prisoners on 25 ozs. of Burma rice and 3 ozs. each of arhar dal and massur dal observed for five consecutive days.

BATCH OF	Quantity of urine.	Re-action.	Total N. of urine.	N. of Burma rice.	N. of arhar and mas-sur dals.	N. of vege-tables.	Weight.
	C. C.		Grms.	Grms.	Grms.	Grms.	Lbs.
Ten Bengali prisoners .	28,560	Acid	69·16	78·50	68·38	4·72	123·2
	23,920	„	67·13	78·50	68·33	4·72	..
	20,430	„	67·59	78·50	68·33	4·72	123·3
	26.930	„	71·39	78·50	68·33	4·72	..
	25,310	„	65·32	78·50	68·33	4·72	123·2

Total N. of intake—
- N. of Burma rice . . 392·50 grms.
- N. of dals . . . 341·65 „
- N. of vegetables . . 23·60 „

Total . =757·75 „

Total output of nitrogen—
- N. of urine . . . 340·59 grms.
- ·5 grm. daily constant . 25·00 „

Total N. metabolism . . =365·59 „
=48·23 per cent. of N. of diet.
=7·31 grms. N. per man daily.

The percentage of nitrogen absorbed by this batch was the lowest obtained in the whole investigation. The reason, so far as we could see, was the condition of the arhar dal which was of very poor quality and badly cleaned. It appeared also to be contaminated with some foreign seed.

(iii) Five prisoners on 25 ozs. of Burma rice and 6 ozs. of massur dal observed over five consecutive days.

Batch A.	Quantity of urine.	Re-action.	N. of Burma rice.	N. of Mas sur dal.	N. of vege-tables.	Weight.	Total N. of urine.
	C. C.		Grms.	Grms.	Grms.	Lbs.	Grms.
Five Bengali prisoners	14,850	Acid	39 25	37·68	2·36	127·6	37·70
	11,290	„	39·25	37·68	2·36	127·8	36·90
	9,590	„	39·25	37·68	2·36	127·8	34·37
	13,250	„	39 25	37·68	2·36	127·6	38·86
	14,240	„	39·25	37·68	2·36	127·6	38·28

Total intake of nitrogen—

N. of Burma rice . .	196·25	grms.
N. of massur dal . .	188·40	„
N. of vegetables . .	11·80	„
Total N. of intake . . .	396·45	„

Total output—

N. of urine	186·11	grms.
·5 grm. daily constant .	12·50	„
Total nitrogenous metabolism	=198·60	„

= 50·10 per cent. of nitrogen of diet
= 7·94 grms. N. per man daily.

(iv) Five prisoners on just over 25 ozs. of Burma rice and 6 ozs. of massur dal observed over five consecutive days.

Batch A.	Quantity of urine.	Re-action.	Total N. of urine.	N. of Burma rice.	N. of massur dal.*	No. of vege-tables.	Weight.
	C. C.		Grms.	Grms.	Grms.	Grms.	Lbs.
Five Bengali prisoners	8,910	Acid	36·73	40·70	34 26	2·36	116·0
	9,100	„	35·79	39·13	34·26	2·36	115·8
	10,440	„	42·55	40·70	34·26	2·36	116·0
	5,600	„	33·80	40·70	34·26	2·36	116·1
	7,350	„	36·76	37 87	34·26	2·36	116·1

Total intake of nitrogen—

N. of Burma rice .	199·10	grms
N. of massur dal .	171·30	„
N. of vegetables .	11·80	„
Total N. of intake .	382·20	„

Total output—

N. of urine	185·63	grms.
·5 grm. daily constant .	12·50	„
Total nitrogenous metabolism .	198·13	„

= 51·84 per cent. of nitrogen of diet.
= 7·92 grms. per man daily.

* A different sample of massur dal from that used in (iii). The two sets of observations were carried out at different seasons of the year (iii) in the cold weather, (iv) in the rains.

(v) Five prisoners on just under 25 ozs. of Burma rice and 6 ozs. of mung dal observed over five consecutive days.

BATCH A.	Quantity of urine.	Re-action.	Total N. of urine.	N. of Burma rice.	N. of mung dal.	N. of vege-tables.	Weight.
	C. C.		Grms.	Grms.	Grms.	Grms.	Lbs.
Five Bengali prisoners	10,830	Acid	39·49	37·62	32·23	2·36	115·9
	7,170	,,	32·77	37·69	32·06	2·36	..
	8,850	,,	36·67	40·17	32·06	2·36	116·0
	9,970	,,	35·43	38·49	32·23	2·36	116
	7,120	,,	36·68	40·17	32·23	2·36	115·9

Total intake of nitrogen—

N. of Burma rice	. 194·14	grms.
N. of mung dal	. 160·81	,,
N. of vegetables	. 11·80	,,
Total N. of intake	. 366·75	,,

Total output—

N. of urine	. 181·04	grms.
·5 grm. daily constant .	. 12·50	,,
Total nitrogenous metabolism	. 193·54	,,

= 52·50 per cent. of N. of diet.
= 7·74 grms. N. per man daily.

We were unable to obtain more observations with anything like the full 26 ozs. of Burma rice consumed, even in those given here there was a decrease from the full scale. However, as the decrease was small we may accept the average of these as showing the degree of nitrogenous metabolism possible on nearly the full ordinary jail diet.

What do we learn from this series ?

By i	an intake of	292·64	grms. nitrogen gives a metabolism of	157·05 grms.
By ii	,, ,,	757·75	,, ,, ,, ,, ,, ,,	365·59 ,,
By iii	,, ,,	396·45	,, ,, ,, ,, ,, ,,	198·60 ,,
By iv	,, ,,	382·20	,, ,, ,, ,, ,, ,,	198·13 ,,
By v	,, ,,	366·75	,, ,, ,, ,, ,, ,,	193·54 ,,
Therefore	an intake of	2195·79	,, ,, ,, ,, ,, ,,	1112·91 ,,

= an average of 50·70 per cent. of the N. of the diet is absorbed.
= the metabolism of 7·69 grms. of N. per man daily.

So that Bengali prisoners are only able to absorb a little over 50 per cent. of the nitrogen of their full diet, which means an average of 7·70 grms. of nitrogen or 48·12 grms. of protein undergoing metabolism daily. Another point brought out in this series, and one to which we shall have occasion to refer to later, is that an increase in the amount of nitrogen given as dal is not accompanied by an increase in the amount of nitrogen undergoing metabolism.

Thus, with practically constant quantities of nitrogen derived from Burma rice and vegetables, but with changing amounts of nitrogen derived from different dals, we get :—

Basis of five men for five days { N. of Burma rice and vegetables } Constant (fairly)

(i)	Arhar dal	150·10 grms. N.	= 196·25 grms. N. absorbed.
(ii)	{ Arhar dal / Massur ,, }	170·87 ,, ,,	= 182·79 grms. N. absorbed.
(iii)	Massur ,,	188·40 ,, ,,	= 198·60 grms. N. absorbed.
(iv)	,, ,,	171·30 ,, ,,	= 198·13 grms. N. absorbed.
(v)	Mung ,,	160·81 ,, ,,	= 193·54 grms. N. absorbed.

Neglecting (ii) in which the arhar dal was of an inferior quality, it is evident that there is practically an identical absorption from the same amounts of arhar dal, massur dal and mung dal, although the quantity of nitrogen furnished by equal quantities of those dals varies considerably.

The practically identical absorption shown by (iii) and (iv) is very interesting; though the amount of nitrogen furnished by the massur dal of (iii) provides 17·10 grammes more than that given in (iv) yet the result is the same. This would tend to corroborate the view that an increase in the nitrogen given as dal is useless in causing increased nitrogenous metabolism, and that the limit of the quantity of dal in the dietaries is reached, if not passed, with 6 ozs. per man daily.

We might look on these figures from another point of view, and deduce that the protein of arhar dal and mung dal is more easily assimilated than that of massur dal. This is very probably the case, and as a matter of fact these dals are considered to be more digestible than the others by the native population.

This is particularly so with regard to arhar dal amongst the Beharis, and, as we shall have occasion to point out later, variations in the absorbability of the protein of the different dals can be made out when the total bulkiness of the diet is decreased. To this, however, we shall return.

(*b*).—Puri Jail, Orissa.

The prisoners in this jail are almost wholly Ooriyas who are very markedly a rice-eating people. The rice used in the jail is grown locally and is therefore country rice. We had no difficulty in getting the full amount of the rice of the jail diet consumed; in fact it was rather the other way, more could have been eaten than the quantity sanctioned in the jail code. The prisoners of this jail were, therefore, particularly well-adapted for experiments in which the amount of rice in the dietaries was diminished, as results corroborating those found in other jails, where the ordinary 26 ozs. of rice was only with difficulty consumed, would be of peculiar value. We took full advantage of this characteristic of the Ooriyas and,

with the sanction of the Inspector-General of Jails, placed the whole population of the jail for six months on diets that contained considerably less rice than the ordinary jail standard. A full report of the results will be found in its proper place ; at present, all we wish to say is that even this rice-eating people, accustomed from infancy to the consumption of enormous quantities of rice, in a short time got used to the altered conditions and became quite contented with their new diets.

The Ooriyas on the other hand are not as a rule very fond of dal, the amount of dal taken daily by the ordinary working population being very small, due largely to the expense of this food material. They are very fond of fish and all those near the coast and close to rivers obtain plenty of fish as a part of their dietary. Most of them, however, live on rice and vegetables as their staple diet.

All we have said, therefore, with regard to the extreme bulkiness of this type of diet and the disabilities attached to it apply with even greater force in the case of the Ooriya than with the Bengali. The result is that the physical development of the Ooriya and his powers of resistance to disease are probably on even a lower scale than those of the average working population of Bengal, when those of both classes who are able to get enough to eat are compared.

Let us see how the rice-eating Ooriya stands with regard to his power of absorbing protein from the ordinary jail diet.

TABLE III.

Investigations to determine the degree of nitrogenous metabolism on a diet composed of the full quantities of the jail scale.

(i) Sixteen prisoners—all Ooriyas—divided into four batches.—Urine of prisoners of each batch pooled. The full diet of 26 ozs. of country rice and 6 ozs. of different dals was consumed.

Observations over three consecutive days.

Batches.	Quantity of urine.	Reaction.	Total N.	Weight.	N. in country rice.	N. in dal.	N. in vegetables, etc.
	C. C.		Grms.	Lbs.	Grms.	Grms.	Grms.
Batch I. Four prisoners	5,260	Acid.	26·70	113·1	32·08	25·75	1·96
	5,160	,,	28·88	..	32·08	24·10	1·96
	5,000	,,	26·90	113·1	32·08	25·20	1·96
Batch II. Four prisoners	3,810	,,	24·19	97·8	32·08	25·75	1·96
	6,230	,,	28·96	..	32·08	24·10	1·96
	6,230	,,	28·74	97·9	32·08	25·20	1·96
Batch III. Four prisoners	3,600	,,	26·28	100·8	32·08	25·75	1·96
	5,100	,,	25·45	..	32·08	24·10	1·96
	6,000	,,	28·89	100·8	32·08	25·20	1·96
Batch IV. Four prisoners	4,750	,,	28·99	108·7	32·08	25·75	1·96
	6,150	,,	28·84	..	32·08	24·10	1·96
	5,600	,,	27·71	108·8	32·08	25·20	1·96

Intake of nitrogen in rice	384·96 grms.	Output—			
,, ,, ,, in dal	300·20 ,,		Nitrogen of urine	330·53 grms.
,, ,, ,, in vegetables	23·52 ,,		·5 grm. daily constant	24·00 ,,
Total N. intake	=708·68 ,,	Total nitrogenous metabolism		354·53 ,,

=50·02 per cent. of the nitrogen of the diet and means the metabolism of 7·38 grms. of nitrogen per man daily.

The different dals in use were mung, gram, kalai and arhar.

(ii) Four prisoners—all Ooriyas.—Urine of prisoners pooled, on a diet of 26 ozs. of country rice and 6 ozs. of arhar dal.

Observations over five consecutive days.

Batch II.	Quantity of urine.	Reaction.	Total N. of urine.	Weight.	N. in country rice.	N. in arhar dal.	N. in vegetables, etc.
	C. C.		grms.	lbs.			
Four prisoners	6,970	Acid.	26·66	98·2	32·08	25·70	1·96
	6,670	,,	28·38	98·2	32·08	25·70	1·96
	6,340	,,	28·48	..	32·08	25·70	1·96
	5,870	,,	27·20	..	32·08	25·70	1·96
	5,780	,,	27·95	98·2	32·08	25·70	1·96

Total intake of nitrogen—

N. of country rice	160·40 grms.
N. of arhar dal	128·50 ,,
N. of vegetables	9·80 ,,
Total nitrogen	298·70 ,,

Output—

N. of urine	138·67 grms.
·5 grm. daily constant	10·00 ,,
Total nitrogenous metabolism	148·67 ,,

=49·78 per cent. of the nitrogen of the diet.
=7·43 grms. of nitrogen per man daily.

(iii) Four prisoners—all Ooriyas—on the full 26 ozs. of country rice and 7 ozs. of gram dal observed over six days.

[7 ozs. of gram dal provides the same amount of nitrogen as 6 ozs. of arhar dal, so that by a comparison of the nitrogenous metabolism of this set of observations with those given above (ii) we have a measure of the relative absorbability of the protein of gram and arhar dals. The two sets of observations are on the same four prisoners.]

Observations over six consecutive days.

BATCH II.	Quantity of urine.	Reaction.	Total N. of urine.	Weight of prisoners.	N. in country rice.	N. in gram dal.	N. in vegetables, etc.
	C. C.		Grms.	Lbs.			
Four prisoners . .	6,760	Acid	26·69	98·8	32·08	25·74	1·96
	4,750	,,	26·93	98·8	32·08	25·74	1·96
	5,325	,,	27·91	..	32·08	25·74	1·96
	5,960	,,	27·70	..	32·08	25·74	1·96
	4,520	,,	26·88	..	32·08	25·74	1·96
	5,430	,,	28·36	98·8	32·08	25·74	1·96

Total intake of nitrogen—
N. of rice . . . 192·48 grms.
N. of gram dal . . 154·44 ,,
N. of vegetables . . 1·76 ,,

Total nitrogen of intake . =358·68 ,,

Output—
N. of urine . . . 164·47 grms.
·5 grm. daily constant . 12·00 ,,

Total nitrogenous metabolism. 176·47 ,,
=49·20 per cent. of the nitrogen of the diet or the metabolism of 7·35 grms. of nitrogen per man daily.

What do we learn from this series ?

By (i) an intake of 708·68 grms. nitrogen gives a metabolism of 354·53 grms.
By (ii) ,, ,, ,, 298·70 ,, ,, ,, ,, ,, ,, 148·67 ,,
By (iii) ,, ,, ,, 358·68 ,, ,, ,, ,, ,, ,, 176·47 ,,

Therefore ,, ,, 1366·06 ,, ,, ,, ,, ,, ,, 679·67 ,,
=49·75 per cent. of the nitrogen of the diet or the metabolism of 7·39 grms. of nitrogen or 46·20 grms. of protein per man daily.

So that the rice-eating Ooriya is only able to absorb just under 50 per cent. of the nitrogen of his diet, which means an average of 7·40 grammes of nitrogen or 46·25 grammes of protein per man daily.

When we compare this result with what was found for the Bengali we see how very closely the figures tally with each other. There is only a difference of 0·30 grm. of nitrogen per man daily in the amounts undergoing metabolism : this result would probably have been even closer if we could have obtained observations on the Bengali when the full quantity of rice was consumed. The full amount of Burma rice of the Bengali diet was not all eaten, so that probably a slightly greater amount of the nitrogen of the diet was absorbed owing to the reduction in bulk. The absorption of protein by the Bengali on his Burma rice diet and by the Ooriya

on country rice are therefore very similar. It would not appear from these observations that country rice has any advantage, so far as its nutritive value is concerned, over Burma rice although it is much preferred by the inhabitants of Bengal including Behar. In fact, so far as these observations touch the question, whatever difference exists is in favour of the Burma variety, that is when the full 26 ozs. are eaten.

In these three sets of observations, the full amount of rice being always consumed, the intake of nitrogen from rice was constant; the intake of nitrogen from dal was also very nearly identical in each; thus,

Basis of five men for five days.	N. of country rice and vegetables constant.	+	(i) Mixed dals 156·35 grms. N.	=184·50 grms. N. absorbed.
			(ii) Arhar dal 160·62 ,, ,,	=185·75 grms. N. absorbed.
			(iii) Gram dal 161·81 ,, ,,	=183·75 grms. N. absorbed.

and, as will be seen, the differences in the amount of nitrogen absorbed between the three sets of results is so close as to be within the limits of experimental error. This affords further proof that with the nitrogen from the other components of a diet constant and the nitrogen from dal (any dal) practically the same, very nearly equal amounts of nitrogen will undergo metabolism.

It is to be noted, however, that it required 7 ozs. of gram dal to provide the same amount of nitrogen as 6 ozs. of arhar dal, and that the substitution of these amounts for each other in the jail dietary is followed by practically an identical absorption. It is quite possible, however, that an equally good absorption would have been obtained if only 6 ozs. of gram dal had been given in the diet; but the aim in view in these experiments was to keep the nitrogen intake as nearly constant as possible.

We may sum up the results of these observations on Bengali and Ooriya prisoners by stating :—

(i) On an average just 50 per cent. of the protein of the full jail diet is absorbed, which means the metabolism of about 7·55 grammes of nitrogen or 47·18 grammes of protein per man daily.

(ii) When rice is given in quantities of 26 ozs. per man daily it does not appear to make any marked difference which variety of rice—Burma or country—is used.

(iii) When 6 ozs. of dal are given, combined with the full 26 ozs. of rice and 6 ozs. of vegetables, it does not appear to matter what kind of dal is made use of—practically an identical absorption is obtained with the same amount of dal in the diet, although the quantities of nitrogen provided by the several dals vary very considerably. This would

lead us to suspect that 6 ozs. of dal per man daily is beyond the amount from which the maximum absorption can take place.

(iv) The results stated in (ii) and (iii) do not justify the assumption that with lesser amounts of rice and dal in the dietaries differences in the absorbability of the protein of these food-stuffs would not take place; or that the absorption from Burma rice and country rice would be identical for different amounts of rice in the diet; or that, if the quantity of dal in the dietary were diminished, the same percentage absorption would occur from the decreased amounts of the several kinds of dal.

(c) RANCHI JAIL, CHOTA NAGPUR.

We now come to deal with an entirely different kind of people—the aboriginal tribes of the Ranchi plateau. The hills around this district are from two to four thousand feet above sea level, so that the inhabitants are very differently situated with regard to climate, temperature, moisture, etc., from what obtains in Bengal proper and Orissa. As is only to be expected also the physique and general stamina, capabilities of work and muscular development is on a higher level than found in Bengal or Orissa. The average size of the individuals of these tribes is not great, but they are hard workers, compared with the Bengali or plain men and very compactly built.

In Ranchi Jail we selected four healthy men from each of the principal tribes for our investigation. All we attempted to do was to obtain the average protein absorption from the diet in use in this jail, which was of the ordinary Lower Bengal type, and to make enquiries regarding any differences in absorption exhibited by the members of these tribes among themselves, or compared to that found for the Bengali. As will be evident from the results marked differences do occur both as regards the several tribes and compared with the Bengali or Ooriya. A study of the causes of these differences is a problem of importance in the question of the corelation of the protein absorption and physical development and we have enlisted the help of Major Maddox, I.M.S., Civil Surgeon of those hills, in collecting information concerning any tribal characteristics that might throw light on this point. At present, all we are concerned with is the average absorption shown by these men when placed on the ordinary jail diet. The significance of these results will be discussed later in the light of the report furnished by Major Maddox, and it will be further dealt with when we come to examine the development and nitrogenous metabolism of the hill tribes of Darjeeling and contrast them among themselves, and with the people of the plains.

In the investigations regarding the protein metabolism on the ordinary jail diet four healthy prisoners from four different tribes were selected, isolated and placed on the diet for a few days before the collection of excreta commenced. Table IV gives the results obtained.

TABLE IV.

Investigations to determine the degree of nitrogenous metabolism occurring on the jail diet amongst representatives of the aboriginal tribes of Chota Nagpur.

Four men under observation for five consecutive days.

Tribe.	Quantity of urine.	Reaction.	Total N. of urine.	N. of rice.	N. of kalai dal.	N. of vegetables.	Weight.
"Pater."	C. C.		Grms.	Grms.	Grms.	Grms.	Lbs.
Four prisoners	10,070	Acid.	34·96	32·08	24·77	1·96	113
	7,980	,,	39·10	32·08	24·77	1·96	112·6
	9,510	,,	37·01	32·08	24·77	1·96	113
	11,000	,,	35·11	32·08	24·77	1·96	113
	12,770	,,	31·56	32·08	24·77	1·96	113

Total intake of nitrogen—

N. of rice	160·40 grms.
N. of kalai dal	123·35 ,,
N. of vegetables	9·80 ,,
Total nitrogen	293·05 ,,

Total output—

N. of urine	177·74 grms.
·5 grm. daily constant	10·00 ,,
Total nitrogenous metabolism	187·74 ,,

=64·06 per cent. of the total nitrogen of the diet.
=9·38 grms. of nitrogen per man daily.

Tribe.	Quantity. of urine.	Reaction.	Total N. of urine.	N. of rice.	N. of kalai dal.	N. of vegetables.	Weight.
"Moonda."	C. C.		Grms.	Grms.	Grms.	Grms.	Lbs.
Four prisoners	7,550	Acid.	34·66	32·08	24·77	1·96	106·6
	9,230	,,	34·50	32·08	24·77	1·96	106·5
	7,630	,,	30·71	32·08	24·77	1·96	106·6
	8,460	,,	29·96	32·08	24·77	1·96	106·6
	10,310	,,	29·73	32·08	24·77	1·96	106·6

Total intake of nitrogen =293·05 grms. Total output—

N. of urine	. . .	159·56 grms.
·5 grm. daily	. . .	10·00 „
Total nitrogenous metabolism		169·56 „

=57·86 per cent. of nitrogen of the diet.
= 8·48 grms. of nitrogen per man daily.

Tribe.	Quantity of urine.	Reaction.	Total N. of urine.	N. of rice.	N. of kalai dal.	N. of vegetables.	Weight.
	C. C.		Grms.	Grms.	Grms.	Grms.	Lbs.
"Swansi."							
Four prisoners . .	4,900	Acid.	36·15	32·08	24·77	1·96	111·3
	6,010	„	42·97	32·08	24·77	1·96	111·2
	4,500	„	34·96	32·08	24·77	1·96	111·3
	5,530	„	34·37	32·08	24·77	1·96	111·3
	7,050	„	32·86	32·08	24·77	1·96	111·3

Total intake of nitrogen =293·05 grms. Total output—

N. of urine	. . . .	181·31 grms.
·5 grm. daily constant	. .	10·00 „
Total nitrogenous metabolism	.	191·31 „

=65·28 per cent. of the nitrogen of the diet.
= 9·56 grms. nitrogen per man daily.

Tribe.	Quantity of urine.	Reaction.	Total N. of urine.	N. of rice.	N. of kalai dal.	N. of vegetables.	Weight.
	C. C.		Grms.	Grms.	Grms.	Grms.	Lbs.
"Uraon."							
Four prisoners . .	6,100	Acid	26·47	32·08	24·77	1·96	109·9
	4,230	„	25·83	32·08	24·77	1·96	109·8
	4,960	„	29·78	32·08	24·77	1·96	109·9
	5,000	„	30·73	32·08	24·77	1·96	110·0
	7,260	„	31·30	32·08	24·77	1·96	110·0

Total intake of nitrogen =293·05 grms

Total output—
N. of urine . . . 144·11 grms.
·5 grm. daily constant . 10·00 „

Total nitrogenous metabolism 154·11 „
=52·58 per cent. of nitrogen of diet.
= 7·71 grms. of nitrogen per man daily.

The rice used in all these experiments was rice grown on the Ranchi plateau. The analysis showed the proximate principles to be practically identical with those obtained from country rice. It is said, however, to be much preferred by the native tribes to any rice grown elsewhere.

What do we learn from this series of observations ?

With the same food materials identical in every particular we have got very different degrees of nitrogenous metabolism among the representatives of the tribes examined, and also great differences compared with the Bengali and Ooriya.

The "Pater" tribesmen absorb 64·06 per cent. of the protein of their diet, which means the metabolism of 9·38 grms. nitrogen or 58·62 grms. of protein per man daily.

The "Moondas" absorb 57·86 per cent. of the total protein of their diet, which means the metabolism of 8·48 grms. nitrogen or 52·90 grms. of protein per man daily.

The "Swansi" tribesmen absorb 65·28 per cent. of the total protein of their diet, which means the metabolism of 9·56 grms. nitrogen or 59·75 grms. of protein per man daily.

The "Uraons" absorb 52·58 per cent. of the total protein of their diet, which means the metabolism of 7·71 grms. nitrogen or 48·18 grms. of protein per man daily.

Put in tabular form the contrast will be evident :—

Tribe or People.	Per cent. of N. No. of diet absorbed.	Grms. of nitrogen per day undergoing metabolism.	Grammes of protein per day undergoing metabolism.
"Pater" and "Swansi" . .	64·06 to 65·28	9·38 to 9·56	58·62 to 59·75
"Moonda" and "Uraon". .	52·58 to 57·86	7·71 to 8·48	48·18 to 52·9
"Bengali" and "Ooriya". .	49·75 to 50·7	7·39 to 7·69	46·20 to 48·12

The absorption of protein and the degree of nitrogenous metabolism possible from practically identical dietaries are markedly higher in the aboriginal tribes "Pater" and "Swansi" than in the two other tribes examined—"Moonda" and "Uraon," or in the inhabitants of the plains of Bengal and Orissa.

SECTION 3.

3. The effect on nitrogenous metabolism of varying the quantities of the components of the ordinary jail diet.

Having worked out the average amount of nitrogen absorbed from the ordinary jail diet, the next step in our investigations was to vary the quantities of the different materials forming the diet, and note the effect on the amount of nitrogen undergoing metabolism. In describing this part of the work we shall give the results of our investigations under three headings :—

(*a*) The effect of varying the amount of rice in the diet when the other constituents are kept constant in quantity.

(*b*) The effects of varying the amount of dal when the other constituents are kept constant in quantity.

(*c*) The effects of varying the amounts of rice and dal when the total nitrogen of the diet is kept constant.

(*a*) *The effect of varying the amount of rice in the diet, the remaining constituents being constant in quantity.*—Ten prisoners on the full diet of Burma rice and arhar dal observed for two consecutive days—see Table II (i)—absorbed 53·66 per cent. of the total nitrogen of the diet, which is equal to the metabolism of 7·85 grms. nitrogen per man daily.

This result—which is slightly higher than the average protein metabolism for Bengalis and Ooriyas on the full jail diet—is to be contrasted with the following in which the quantity of Burma rice is decreased, the other components remaining constant.

TABLE V.

(i) Investigations on the degree of nitrogenous metabolism on the jail diet when the amount of Burma rice is reduced from 26 ozs. to 19½ ozs. per man daily, the ordinary 6 ozs. of arhar dal being constant.

Five prisoners observed for five consecutive days.

Batch A.	Quantity of urine.	Reaction.	Total N. of urine.	N. of rice.	N. of arhar dal.	N. of vegetables.	Weight.
Five Prisoners.	C. C.		Grms.	Grms.	Grms.	Grms.	Lbs.
	9,230	Acid.	40·38	31·30	28·90	2·36	115
One Hindu . . .	6,270	„	37·83	24·87	30·10	2·36	114·8
Four Mahomedans .	8,420	„	39·37	31·30	29·40	2·36	114·6
	7,450	„	39·00	30·80	30·10	2·36	115·1
	8,150	„	42·77	31·30	30·10	2·36	115

Total N. of intake—
N. of rice . . . . 149·57 grms.
N. of arhar dal . . 148·66 „
N. of vegetables . . 11·80 „

Total N. of intake . . 310·03 „

Total output —
N. of urine . . 199·35 grms.
·5 grm. daily constant 12·50 „

Total N. metabolised =211·85 „
=68·33 per cent. of total N. of diet.
= 8·47 grms. per man per day.

From this result we find that, under exactly the same conditions as regards food-material, a reduction of the quantity of rice in the ordinary jail diet is at once followed by a great increase in the percentage of nitrogen absorbed from the diet, and, at the same time, by a large increase in the actual amount of protein undergoing metabolism. Thus :—

Table II (i).—From 26 ozs. Burma rice and 6 ozs. arhar dal 7·85 grms. nitrogen are absorbed, which is 53·66 per cent. of nitrogen of diet.

Table V (i).—From 19 ozs. Burma rice and 6 ozs. arhar dal 8·47 grms. nitrogen are absorbed, which is 68·33 per cent. of nitrogen of diet.

These two sets of observations are absolutely comparable for the dal given was the same in kind and quantity in each ; in fact the only point open to the least doubt is that the metabolism of 7·85 grms. nitrogen is perhaps too high, due to the prisoners having been observed for only two days ; but it was not possible to get them to take the full quantity of rice longer. So that the increase in the amount of nitrogen undergoing metabolism and the increase in the percentage of the nitrogen of the diet absorbed, when a decrease in the quantity of rice from 26 ozs. to 19 ozs. took place, would probably be even slightly greater than we have shown.

This effect of decreasing the amount of rice may be due either to the lessened bulkiness of the diet permitting of a better percentage absorption of the protein of the rice or of the dal or, as most probably is the true explanation, to an increased protein absorption from both rice and dal.

(ii) Investigations on the degree of nitrogenons metabolism on the jail diet when the amount of Burma rice is reduced from 26 ozs. to just under 23 ozs. per man daily, the ordinary 6 ozs. of mattar dal being constant.

Five prisoners observed for five consecutive days.

Batch A.	Quantity of urine.	Reaction.	Total N. of urine.	N. of rice.	N. of mattar dal.	N. of vegetables.	Weight.
Five Prisoners.	C. C.		Grms.	Grms.	Grms.	Grms.	Lbs.
	7,680	Acid.	37·05	35·24	29·66	2·36	115
One Hindu . .	8,760	„	36·97	36·41	29·66	2·36	115
Four Mahomedans . .	8,496	„	37·27	36·94	29·66	2·36	114·9
	10,010	„	40·58	35·69	29·66	2·36	114·8
	8,530	„	38·06	34·75	29·66	2·36	114·9

Total N. intake—		Total output—		
N. of rice .	179·03 grms.	N. of urine	189·93 grms.	
,, ,, mattar dal	148·30 ,,	·5 grm. N. daily constant .	12·50 ,,	
,, ,, vegetables	11·80 ,,			
		Total nitrogenous metabolism	202·43 ,,	
Total N. intake .	=339·13 ,,	= 59·69 per cent. of nitrogen of diet and means the metabolism of 8·09 grms. of nitrogen per man daily.		

These observations are also strictly comparable with those shown in (i) of this table. It will be seen that the nitrogen of the dal and vegetables is the same in both sets, and that the only variation is in the amount of nitrogen from Burma rice. The percentage absorption and protein metabolism show the usual increase following a diminution in the amount of rice to 23 ozs. per man daily.

Therefore with strictly comparable results we get :—

With 26 ozs. Burma rice + 5·98 grms. N. from arhar dal 7·85 grms. N. are absorbed.
,, 23 ,, ,, ,, + 5·93 ,, ,, ,, mattar ,, 8·09 ,, ,, ,,
,, 19 ,, ,, ,, + 5·98 ,, ,, ,, arhar ,, 8·47 ,, ,, ,,

(iii) Comparison of the degree of protein metabolism on diets containing the same amounts of nitrogen in the form of massur and mattar dals, but in which the quantity of Burma rice varied—in the first diet 24 ozs. were consumed, in the second 20 ozs. were consumed.

Diet I

Ten prisoners observed for five consecutive days.

Batch.	Quantity of urine.	Re-action.	Total N. of urine.	N. of rice.	N. of massur dal.	N. of mattar dal.	N. of vegetables.	Weight.
	C. C.		Grms.	Grms.	Grms.	Grms.	Grms.	Lbs.
Ten prisoners, Bengalis .	16,590	Acid.	73·78	75·94	34·26	29·66	4·72	115·5
	17,860	,,	72·76	75·54	34·26	29·66	4·72	115·4
	18,930	,,	79·82	77·64	34·26	29·66	4·72	115·5
	15,610	,,	74·38	76·39	34·26	29·66	4·72	115·5
	15,880	,,	74·82	72·62	34·26	29·66	4·72	115·5

Total nitrogen intake—

N. of Burma rice .	378·13 grms.
N. of massur dal .	171·30 ,,
N. of mattar dal .	148·30 ,,
N. of vegetables .	23·60 ,,
Total nitrogen intake .	721·33 ,,

Total output—

N. of urine	375·6 grms.
·5 grm. daily constant . .	25·00 ,,
Total nitrogenous metabolism .	400·56 ,,

=55·39 p.c. of the total nitrogen of the diet
= 8·00 grms. of nitrogen per man daily.

Diet II.

Five prisoners observed for five consecutive days.

BATCH.	Quantity of urine.	Reaction.	Total N. of urine.	N. of rice.	N. of massur dal.	N. of mattar dal.	N. of vegetable.	Weight.
	C. C.		Grms.	Grms.	Grms.	Grms.	Grms.	Lbs.
Five prisoners, Bengalis .	8,820	Acid	43·46	31·30	17·13	14·83	2·36	115·8
	9,260	,,	37·46	31·30	17·13	14·83	2·36	115·7
	8,470	,,	38·53	31·30	17·13	14·83	2·36	115·6
	8,930	,,	38·50	31·30	17·13	14·83	2·36	115·8
	6,700	,,	39·61	31·30	17·13	14·83	2·36	115·8

Total intake of nitrogen—

N. of Burma rice . .	156·50 grms.
N. of massur dal . .	85·65 ,,
N. of mattar dal . .	74·15 ,,
N. of vegetables . .	11·80 ,,
Total nitrogen intake .	328·10 ,,

Total output—

N. of urine . . .	197·56 grms.
·5 grm. N. daily constant .	12·50 ,,
Total nitrogenous metabolism	210·06 ,,

= 64·03 per cent. of the nitrogen of the diet.
= 8·40 grms. nitrogen per man daily.

Therefore, from these investigations we again obtain evidence supporting the other results: that a decrease in the quantity of rice of the diet is followed by an increased protein metabolism.

The results obtained from these two diets are strictly comparable as the amount of rice alone varied—the other constituents of the diet remaining the same in kind and amount throughout both periods of observations.

Results contrasted :—

With 24 ozs. Burma rice + 6·39 grms. N. from mattar and massur dals 8·00 grms absorbed.

With 20 ozs. Burma rice + 6·39 grms. N. from mattar and massur dals 8·40 grms. absorbed.

Assuming that the same quantity of nitrogen will be absorbed from the 6 ozs.

of the different dals used in (i), (ii) and (iii) of this table, we may state the results in the following way :—

		Per cent. of nitrogen of diet absorbed.	Grms. of nitrogen absorbed.	Grms. of protein absorbed.
Dals, vegetables, etc., constant.	26 ozs. Burma rice .	53·66	7·85	49·12
	24 " " " .	55·39	8 00	50·00
	23 " " " .	59·69	8·09	50·56
	20 " " " .	64·03	8·40	52·50
	19 " " " .	68·33	8·47	52·93

Contrast this with the average results for Bengalis and Ooriyas :—

Full jail diet	50·00	7·55	47·18

We have, therefore, very strong evidence from these observations that a decrease in the quantity of rice from the 26 ozs. of the jail diet to 19 ozs. permits of a much better absorption of the protein of the diet. In order to confirm this view two sets of investigations were arranged in which, as far as possible, the same five men were observed on diets containing different quantities of rice, while the dal remained the same in kind and amount throughout the periods during which they were under investigation.

(iv) Investigation of the degrees of nitrogenous metabolism on diets based on the following scheme.

Constants . . Massur dal 30 ozs. . Vegetables 30 ozs., etc.	+	Burma rice 100 ozs. " " 125 " " " 90 "	= Diet I = Diet II = Diet III

Diet I.

Five prisoners observed for five days.

Batch A.	Quantity of urine.	Total N. of urine.	N. of Burma rice.	N. of massur dal.	N. of veget-ables.	Weight.	Result.
	C. C.	Grms.	Grms.	Grms.	Grms.	Lbs.	
Five prisoners, Bengalis.	11,860	37·02	31·40	37·68	2·36	125·8	Absorption 56·87 per cent. of N. of diet = 8·12 grms. N. per day per man.
	13,400	39·73	31·40	37·68	2·36	125·7	
	10,790	35·65	31·40	37·68	2·36	125·7	
	12,320	38·28	31·40	37·68	2·36	125·8	
	12,890	39·99	31·40	37·68	2·36	126·0	

Diet II.

BATCH A.	Quantity of urine.	Total N. of urine.	N. of Burma rice.	N. of massur dal.	N. of veget-ables.	Weight.	Result.
Five prisoners, Bengalis.	14,850	37·70	39·25	37·68	2·36	127·6	50·10 per cent. of N. of diet 7·94 grms. of N. per day per man.
	11,290	36·90	39·25	37·68	2·36	127·8	
	9,590	34·37	39·25	37·68	2·36	..	
	13,250	38·86	39·25	37·68	2·36	..	
	14,240	38·28	39·25	37·68	2·36	129·6	

Diet III.

BATCH A.	Quantity of urine.	Total N. of urine.	N. of Burma rice.	N. of massur dal.	N. of veget-ables.	Weight.	Result.
Five prisoners, Bengalis.	10,110	38·82	28·26	37·68	2·36	128·0	59·17 per cent. N. of diet 8·12 grms. of N. per day per man.
	10,880	38·84	28·26	37·68	2·36	127·9	
	10,900	36·77	28·26	37·68	2·36	127·8	
	9,820	36·84	28·26	37·68	2·36	127·8	
	10,260	39·35	28·26	37·68	2·36	128·0	

What is to be learned from the results of these three diets ?

Diet I.

Total intake—		Total output—	
N. of rice . . .	157·00 grms.	N. of urine	190·67 grms.
N. of dal . . .	188·40 „	·5 grms. daily constant . .	12·50 „
N. of vegetables . .	11·80 „		
Total N. intake . .	357·20 „	Total N. metabolism . .	203·17 „
		= 56·87 per cent. of N. of diet	
		= 8·12 grms. per day per man.	

Diet II.

Total intake—		Total output—	
N. of rice . . .	196·25 grms.	N. of urine	186·11 grms.
N. of dal . . .	188·40 „	·5 grm. daily constant . .	12·50 „
N. of vegetables . .	11·80 „		
Total N. of intake . .	396·45 „	Tota N. metabolism . . .	198·61 „
		= 50·10 per cent. of N. of diet	
		= 7·94 grms. per day per man.	

Diet III.

Total intake—
N. of rice . . . 141·30 grms.
N. of dal . . . 188·40 „
N. of vegetables . . 11·80 „

Total N. of intake . . 341·50 „

Total output—
N. of urine . . . . 190·62 grms.
·5 grm. daily constant . . 12·50 „

Total N. metabolism . . 203·12 „
=59·47 per cent. of N. of diet
= 8·12 grms. N. per day per man.

Therefore we get the following results :—

			Grms. of N. absorbed.	Per cent. of N. absorbed.
Massur Dal 6 ozs. Vegetables 6 „ +	Rice 20 ozs.	= Diet I .	. 8·12	56·87
	„ 25 „	= Diet II .	. 7·94	50·10
	„ 18 „	= Diet III .	. 8·12	59·47

(v) Investigations of the degrees of nitrogenous metabolism on diets composed of Burma rice, arhar dal and vegetables. The amounts of dal and vegetables were kept constant, but the quantity of Burma rice varied in each diet.

Constants.

Arhar dal 30 ozs., Vegetables 30 ozs., etc.	Burma rice 100 ozs.	= Diet I.
	„ „ 125 „	= Diet II.
	„ „ 90 „	= Diet III.

Diet I.

Five prisoners observed for five days.

Batch B.	Quantity of urine.	Total N. of urine.	N. of Burma rice.	N. of arhar dal.	N. of vegeta-bles.	Weight.	Result.
	C. C.	Grms.	Grms.	Grms.	Grms.	Lbs.	
Five prisoners, Bengalis.	15,150	35·63	31·40	30·65	2·36	115·8	Absorption 53·36 per cent. of N. of diet 6·87 grms. of N. per day per man.
	14,000	34·59	31·40	30·65	2·36	115·9	
	11 660	32·48	31·40	30·65	2·36	116·1	
	12,850	29·32	31·40	30·65	2·36	115·8	
	12,350	27·34	31·40	30·65	2·36	115·9	

Diet II.

Batch B.	Quantity of urine.	Total N. of urine.	N. of Burma rice.	N. of arhar dal.	N. of vegetables.	Weight.	Result.
	C. C.	Grms.	Grms.	Grms.	Grms.	Lbs.	
Five prisoners, Bengalis.	14,270	31·46	39·25	30·65	2·36	118·8	44·80 per cent. of N. of diet = 6·48 grms. N. per day per man.
	12,630	30·23	39·25	30·65	2·36	118·6	
	10.840	28·22	39·25	30·65	2·36	118·6	
	13,670	32·53	39·25	30·65	2·36	118·9	
	11,070	27·04	39·25	30·65	2·36	118·9	
Diet III.							
Five prisoners, Bengalis.	9,400	27·30	28·26	30·65	2·36	116·2	56·86 per cent. of N. of diet =6·97 grms. N. per day per man.
	9 810	23·09	28·26	30·65	2·36	116·2	
	9,430	25·35	28·26	30·65	2·36	116·3	
	9,620	26·86	28·26	30·65	2·36	116	
	6,230	26·77	28·26	30·65	2·36	116·2	

What is to be learned from these results ?

Diet I.

Total intake—

N. of Burma rice . . .	157·00 grms.
N. of arhar dal . . .	153·25 „
N. of vegetables . . .	11·80 „
Total N. of intake . . .	322·05 „

Total output—

N. of urine . . .	159·36 grms.
·5 grm. constant daily .	12·50 „
Total N. metabolism . .	171·86 „

=53·36 per cent. of N. of diet
= 6·87 grms. of N. per day per man.

Diet II.

Total intake—

N. of Burma rice . . .	196·25 grms.
N. of arhar dal . . .	153·25 „
N. of vegetables . . .	11·80 „
Total N. of intake . . .	361·30 „

Total output—

N. of urine . . .	149·48 grms.
·5 grm. constant . .	12·50 „
Total N. metabolism . .	161·98 „

=44·80 per cent. of N. of diet
= 6·48 grms. of N. per day per man.

Diet III.

Total intake—			Total output—		
N. of Burma rice	. 141·30	grms.	N. of urine (corrected for 5 men)	161·71	grms.
N. of arhar dal .	. 153·25	„	·5 grm. per day constant . .	12·50	„
N. of vegetables	. 11·80	„			
			Total N. metabolism . . .	174·21	„
Total N. of intake.	. 306·35	„	=56·86 per cent. of N. of diet		
			= 6·97 grms. of N. per day per man.		

Therefore we get the following results :—

			Grms. of N. absorbed.	Per cent. of N. of diet absorbed.
Arhar dal 6 ozs. Vegetables 6 ozs.	Burma rice 20 ozs.	= Diet I .	6·87	53·36
	„ „ 25 „	= Diet II .	6·48	44·80
	„ „ 18 „	= Diet III .	6·97	56·86

We thus learn that the actual amount of nitrogen absorbed, from a diet composed of 6 ozs. each of arhar dal and vegetables, combined with Burma rice in varying quantities of 20, 25 and 18 ozs. per man daily, is least when the quantity of rice is 25 ozs., greatest when the amount of rice is 18 ozs. and only slightly different when 20 ozs. of rice are consumed. These observations again confirm the results already obtained in previous investigations.

It is worthy of note that in both these sets of investigations—with massur dal and arhar dal—although the chemical analyses of the dals gave a fairly high percentage of protein, it was anticipated at the time that the absorption of protein from the diets would be low. The reason for this opinion was the inferior quality of these dals in appearance, and the numerous blackened grains present in the samples. The results show a diminution in the actual quantity of nitrogenous metabolism compared with those obtained earlier in the year when the food-stuffs were in a fresher condition. Nevertheless, the general effect is practically the same, although on a somewhat lower level, as to the influence of the quantity of rice eaten in the daily diet, *i.e.*, the maximum protein absorption is obtained from a diet composed of rice and dal, when the rice is given in an amount of from 18 to 20 ozs. per man daily—the dal, vegetables, etc., of the diet remaining constant.

(*b*) *The effect of varying the amount of dal when the other constituents of the diet are kept constant.*—We have already had a certain amount of evidence that it is useless to increase the nitrogen of the diet by addition of dal beyond a certain optimum amount, just as it is useless to increase the amount of rice of the diet

beyond the optimum quantity, in the hope to obtain an augmented protein absorption. Thus, we showed in a summary of Table II that, with a practically constant intake of nitrogen from rice but with a varying intake of nitrogen derived from dal, no increase in nitrogenous metabolism accompanied an augmented nitrogen content of the diet from dal.

The figures in support of this view on the basis of batches of five men under observation for five days are :—

Nitrogen of rice and vegetables constant.	N. of arhar dal	150·10	grms. gave	196·25	grms.	absorbed.
	N. of massur ,,	188·40	,, ,,	198·60	,,	,,
	N. of ,, ,,	171·30	,, ,,	198·13	,,	,,
	N. of mung ,,	160·81	,, ,,	193·54	,,	,,

That is, a certain amount of the protein of dal and rice is capable of being absorbed from a diet composed of 26 ozs. of rice and 6 ozs. of dal, and, so far as our observations go, the amount of nitrogen provided by those 6 ozs. does not appear to make any difference in the quantity of protein undergoing metabolism. The results obtained in Puri jail—Table III—bear this out ; however, the quantities of nitrogen furnished in the different observations in that jail were too similar to afford much assistance.

The investigations in which gram dal was used show that practically the same number of grms. of nitrogen undergo metabolism with 7 ozs. of gram dal as when 6 ozs. of other dals are given. This is shown for Puri jail thus :—

Basis of five men under observation for five days.

Nitrogen of rice and vegetables constant.	N. of mixed dals	156·35 gave	184·50	grms.	absorbed.
	N. of arhar dal	160·62 ,,	185·75	,,	,,
	N. of gram dal	161·81 ,,	183·75	,,	,,

In order to clear up the question whether 6 ozs. of dal gives the maximum nitrogen absorption, or whether as good absorption would be obtained by decreasing or increasing the amount of dal in the diet, the following observations were made.

As there was no hope of having the full 26 ozs. of Burma rice consumed, the investigations were carried out with a constant quantity of 20 ozs. of Burma rice. This, of course, introduces a new factor compared with the conditions prevailing when the full diet is given, as the reduction of the diet in bulk may allow of an increased absorption of dal when given in quantities of 6 ozs. or even when those quantities are increased. The investigations were arranged so that the five men

were observed while on diets containing the same quantities of Burma rice, the amounts of dal in the different diets varying.

TABLE V(*a*).

(*i*) Investigations of the degrees of nitrogenous metabolism on diets based on the following scheme :—

Five prisoners observed for periods of five days.

CONSTANTS.

Constants			
Rice 100 ozs. Vegetables 30 ozs.	+	Arhar dal 35 ozs.	= Diet I.
		,, ,, 30 ,,	= Diet II.
		,, ,, 25 ,,	= Diet III.

Diet I.

BATCH B.	Quantity of urine.	Total N. of urine.	N. of Burma rice.	N. of arhar dal.	N. of vege-tables.	Weight.	REMARKS.
	C. C.	Grms.	Grms.	Grms.	Grms.	Lbs.	
Four prisoners, Bengalis.	11,820	31·02	31·40	35·76	2·36	117·2	Corrected to a basis of five men for comparison.
	10,910	31·69	31·40	35·76	2·36	117·1	
	9,680	28·96	31·40	35·76	2·36	117·1	
	12,550	35·14	31·40	35·76	2·36	117·3	
	10,950	33·72	31·40	35·76	2·36	117·3	
Diet II.							
Batch B	15,150	35·63	31·40	30·65	2·36	115·8	
	14,000	34·59	31·40	30·65	2·36	..	
	11,360	32·48	31·40	30·65	2·36	116·0	
	12,850	29·32	31·40	30·65	2·36	115·8	
	12,350	27·34	31·40	30·65	2·36	115·9	

Diet III.

Batch B.	Quantity of urine.	Total N. of urine.	N. of Burma rice.	N. of Arhar dal.	N. of vegetables.	Weight.	Remarks.
	C. C.	Grms.	Grms.	Grms.	Grms.	Lbs.	
	16,460	38·02	31·40	25·54	2·36	117·8	
	13,470	34·88	31·40	25·54	2·36	117·8	
	10,680	30·35	31·40	25·54	2·36	117·6	
	11,740	33·69	31·40	25·54	2·36	117·8	
	13,430	32·52	31·40	25·54	2·36	117·8	

What is to be learned from these results ?

Diet I.

Burma rice 20 ozs., arhar dal 7 ozs. per man.

Total intake of nitrogen—

N. of rice	. .	157·00 grms.
N. of arhar dal	. .	178·80 ,,
N. of vegetables	. .	11·80 ,,
Total N. intake	. .	347·60 ,,

Total output—

N. of urine	. . . .	160·53 grms.
·5 grm. daily constant	. .	12·50 ,,
Total nitrogenous metabolism	.	173·03 ,,

= 49·77 per cent. of total nitrogen of the diet

= 6·92 grms. nitrogen per man daily.

Diet II.

Total intake of nitrogen—

N. of rice	. .	157·00 grms.
N. of arhar dal	.	153·25 ,,
N. of vegetables	.	11·80 ,,
Total N. intake	.	322·05 ,,

Total output—

N. of urine	. . .	159·36 grms.
·5 grm. daily constant	.	12·50 ,,
Total N. metabolism	. .	171·86 ,,

= 53·36 per cent. of total nitrogen of the diet.

= 6·87 grms. nitrogen per man daily.

Diet III.

Total intake of nitrogen—		Total output—	
N. of rice . .	157·00 grms.	N. of urine . . .	169·46 grms.
N. of arhar dal .	127·70 „	5 grms. N. daily constant .	12·50 „
N. of vegetables .	11·80 „		
		Total N. metabolism .	181·96 „
Total N. intake .	296·50 „	= 61·40 per cent. of the nitrogen of the diet.	
		= 7·28 grms. of nitrogen per man daily.	

Therefore we get the following results :—

Constants.		Grms. of N. absorbed.	Per cent. of N. of diet absorbed.
Burma rice 20 ozs. . Vegetables 6 ozs. . } +	Arhar dal 7 ozs.	6·92	49·77
	„ „ 6 „	6·87	53·66
	„ „ 5 „	7·28	61·40

That is, by increasing the quantity of arhar dal from 6 to 7 ozs. per man daily there is practically no increase obtained in the amount of protein of the diet undergoing metabolism, while a decrease in the arhar dal from 6 to 5 ozs. cases a slight increase in the protein metabolism. As would be expected the percentage absorption of nitrogen with 7 ozs. of arhar dal in the diet is very low, considering that the rice has been decreased to 20 ozs., while it shows a distinct increase when the arhar dal is reduced to 5 ozs. daily.

[The arhar dal in use in these observations was that which gave such poor results as to its absorption in other experiments—see Table V (v)—probably from its inferior quality and from the fact that it had been in store all the year with the result that many seeds had become blackened.] The results, however, despite this, are comparable for the three diets and show that, in all probability, the optimum amount of dal is exceeded in a diet of the Lower Bengal jail type which contains 6 ozs. of dal daily.

(ii) **Investigations to show the effect of a reduction of massur dal from 6 to 5 ozs. per man daily, while the other constituents of the diet are constant.**

Rice and vegetables constant. + { 30 ozs. massur dal = Diet I.
25 ozs. massur dal = Diet II. }

The figures for Diet I will be found on Table V (iv), Diet I of this Chapter, the results showing an absorption, with 20 ozs. Burma rice and 6 ozs. of massur dal, of 8·12 grms. nitrogen per man daily, which means 56·87 per cent. of nitrogen of the diet.

Diet II.

BATCH A.	Quantity of urine.	Total N. of urine.	N. of Burma rice.	N. of massur dal.	N. of vegetables.	Weight.	REMARKS.
	C. C.	Grms.	Grms.	Grms.	Grms.	Lbs.	
Five prisoners, Bengalis.	13,960	38·98	31·40	31·40	2·36	126·4	
	13,350	37·94	31·40	31·40	2·36	126·4	
	10,080	38·44	31·40	31·40	2·36	126·6	
	12,120	38·17	31·40	31·40	2·36	126·5	
	11,870	35·89	31·40	31·40	2·36	126·5	

Total intake of nitrogen—
N. of Burma rice . . 157·00 grms.
N. of massur dal . . 157·00 „
N. of vegetables . . 11·80 „

Total nitrogen intake . 325·80 „

Total output—
N. of urine . . . 189·42 grms.
5 grm. nitrogen daily constant. 12·50 „

Total nitrogenous metabolism 201·92 „
= 61·97 p. c. of the nitrogen of the diet.
= 8·06 grms. of nitrogen per man daily.

Therefore we get —

		Grms. N. absorbed.	Per cent. of N. of diet absorbed.
Burma rice 20 ozs.	Massur dal 6 ozs. .	8·12	56·87
Vegetables 6 „	Massur dal 5 ozs. .	8·06	61·97

That is, practically the same amount of nitrogen is absorbed from a diet containing 5 ozs. of massur dal daily as when 6 ozs. are given; so that it would appear from this result also that 6 ozs. of dal in the ordinary jail dietaries is beyond the amount from which the maximum protein absorption takes place.

(iii) That it is useless to increase the amount of nitrogen beyond that provided by 6 ozs. per man daily is further borne out by the following summary of results obtained when the full jail diet was eaten and when 1 oz. per man daily more dal was added.

Diet of 26 ozs. country rice and 6 ozs. mung dal — nitrogen absorbed 187·28 grms.
,, 26 ozs. ,, ,, ,, 7 ,, ,, ,, — ,, ,, 185·57 grms.

These observations were carried out on the same prisoners for five days and are therefore strictly comparable.

We may conclude from the results of these three sets of observations that there is nothing to be gained by trying to increase the amount of protein in the jail dietaries by adding more dal to the 6 ozs. already provided in the jail scales. The protein absorption is quite as good from a diet of the Lower Bengal jail type with 6 ozs. of dal as when 7 ozs. are given. Further, we have brought forward evidence to show that the absorption is equally good when the dal of the jail dietary is reduced to 5 ozs. per man daily, and that it is highly probable that the amount of dal given in the jail diet, when combined with 26 ozs. or even 20 ozs. of rice and 6 ozs. of vegetables, exceeds the quantity from which the maximum absorption is possible.

(c) *The effects of varying the amounts of rice and dal—the total nitrogen of the diets remaining constant.*—It will be evident from the results hitherto obtained, *i.e.*, a decrease in the amount of rice or dal from the ordinary Bengal jail standard being followed by an increase in the amount of protein undergoing metabolism, that no fixed or constant co-efficients of absorbability for the protein of rice or dal would explain the variations in absorption that accompanied changes in the amounts of those substances in the dietaries. The only explanation possible appears to be that for varying quantities of rice or dal varying co-efficients of absorbability must hold—these co-efficients varying to some extent inversely with the quantities of the food materials forming the diet.

In order to obtain some idea of those variations we arranged for a series of observations in which, while the amount of nitrogen furnished by the diets remained fairly constant, the individual constituents of the diets were markedly varied.

TABLE VI.

The diets of these investigations were as follows :—

Diet I.—The ordinary jail diet { 26 ozs. Burma rice. 6 ozs. mung dal.

Diet II.—Rice reduced to 16 ozs. Dal increased to 8·4 ozs.

Diet III.—Rice increased to 32 ozs. Dal reduced to 4 ozs.

Diet I.

Five prisoners for five consecutive days.

Batch A.	Quantity of urine.	Reaction.	Total N. of urine.	N. of rice.	N. of mung dal.	N. of vegetables.	Weight.
	C. C.		Grms.	Grms.	Grms.	Grms.	Lbs.
Five prisoners .	10,830	Acid	39·62	37·62	32·23	2·36	115·9
	7,170	,,	32·77	37·69	32·06	2·36	115·6
	8,850	,,	36·67	41·17	32·06	2·36	116
	9,970	,,	35·43	37·49	32·26	2·36	116
	7,120	,,	36·68	41·17	32·20	2·36	115·9

Total intake of nitrogen—

N. of Burma rice .	194·14	grms.
N. of mung dal . .	160·81	,,
N. of vegetables . .	11·80	,,
Total N. of intake	366·75	,,

Total output—

N. of urine . . .	181·04	grms.
·5 grm. daily constant .	12·50	,,
Total nitrogenous metabolism	193·54	,,

= 52·50 per cent. of the nitrogen of the diet.
= 7·74 grms. nitrogen per man daily.

Diet II.

Five prisoners for six consecutive days.

Batch A.	Quantity of urine.	Reaction.	Total N. of urine.	N. of rice.	N. of mung dal.	N. of vegetables.	Weight.
	C. C.		Grms.	Grms.	Grms.	Grms.	Lbs.
Five prisoners .	7,410	Acid	41·70	24·80	45·50	2·36	114
	6,230	,,	36·19	24·80	45·50	2·36	113·8
	8,050	,,	40·79	24·80	44·88	2·36	113·5
	8,830	,,	39·62	24·80	45·50	2·36	114
	7,800	,,	39·36	24·80	45·50	2·36	114
	8,870	,,	42·58	24·80	45·50	2·36	114

Total intake—
N. of rice . . 148·80 grms.
N. of mung dal . 272·38 „
N. of vegetables . 14·16 „

Total N. of intake . 435·34 „

Total output—
N. of urine . . . 240·24 grms.
Constant ·5 grm. daily . 15·00 „

Total N. metabolised . 255·24 „
= 58·86 per cent. of total N. of diet.
= 8·51 grms. of N. per day per man.

Diet III.

The same five prisoners for five consecutive days.

Batch A.	Quantity of urine.	Reaction.	Total N. of urine.	N. of rice.	N. of mung dal.	N. of vegetables.	Weight.
	C. C.	Grms.	Grms.	Grms.	Grms.	Grms.	Lbs.
Five prisoners, Bengalis	8,420	Acid	29·82	49·60	21·66	2·36	115·6
	7,700	„	29·64	46·60	21·66	2·36	116
	8,380	„	31·38	49·60	21·66	2·36	116·4
	11,280	„	29·92	46·02	21·66	2·36	..
	10,640	„	30·61	46·17	21·66	2·36	116·2

Total N. of intake—
N. of rice . 237·99 grms.
N. of mung dal . 108·30 „
N. of vegetables. 11·80 „

Total N. of intake 358·09 „

Total output—
N. of urine . . . 151·37 grms.
Constant ·5 grm. daily . 12·50 „

Total nitrogenous metabolism 163·87 „
= 45·76 per cent. of total nitrogen of diet.
= 6·55 grms. of nitrogen per man daily.

Therefore we obtain from these observations :—

Diet I—Burma rice 25 ozs., Mung dal 6 „ } 52·50 per cent. of N. absorbed 7·74 grms. N. per man daily.
Diet II—Burma rice 16 „, Mung dal 8·4 „ } 58·86 „ „ „ „ 8·51 „ „ „ „ „
Diet III—Burma rice 32 „, Mung dal 4 „ } 45·76 „ „ „ „ 6·55 „ „ „ „ „

Now the actual amount of nitrogen absorbed from these different quantities of mung dal will be very nearly identical—we saw it was useless to increase the amount of dal in a diet beyond 6 ozs. per man daily, so that little of the increase in the nitrogen absorbed in Diet II will be due to the addition of 2·4 ozs. of mung dal. It, therefore, follows that there must be an increased percentage absorption of the protein of rice and a decreased percentage absorption of the protein of dal

in Diet II compared with Diet I. By a similar line of reasoning it may be accepted that in Diet III there is a decreased percentage absorption of the protein of rice and an increased percentage absorption of the protein of mung dal, even though less nitrogen is absorbed from the 4 ozs. of mung dal of Diet III than from the 6 ozs. of Diet I. As the amount of the nitrogen intake is practically identical in the three diets, and as very different amounts of nitrogen are absorbed in each case—

Diet I	intake of nitrogen	14·67	grms.	N. absorbed	7·74 grms.
Diet II	,, ,, ,,	14·51	,,	,, ,,	8·51 ,,
Diet III	,, ,, ,,	14·34	,,	,, ,,	6·55 ,,

it follows that no constant or fixed co-efficients of absorbability of the protein of rice and dal are possible that will explain the absorption exhibited from these three diets. The only explanation is, therefore, that for varying amounts of rice in the diet there is a varying co-efficient of protein absorption, and that for varying amounts of dal in the diet there is likewise a varying co-efficient of protein absorption—these co-efficients of absorption varying inversely with the amount of rice or dal in the dietaries.

Assuming that about the same absorption of nitrogen takes place from the different quantities of dal in the diets, we may make use of the figures for the amounts of protein absorbed as a measure of the nitrogenous metabolism on diets containing 25, 16 and 32 ozs. of rice, and combining these with the results shown in the foregoing tables, we can plot out the curve of the nitrogenous absorption from diets containing varying quantities of rice, when the absorption of nitrogen from the dal of the dietaries is fairly constant. In this curve* the extreme figures—those for 16 ozs. and 32 ozs. of rice—are probably not quite correct: when the rice is reduced to 16 ozs. in all probability more nitrogen would be absorbed from 8·4 ozs. of mung dal than from 6 ozs., and when the dal is reduced to 4 ozs. per day probably a little less than the quantity of nitrogen absorbed from 6 ozs. of mung dal would be absorbed from 4 ozs. when the diet contains 32 ozs. of rice. With these possible exceptions the curve obtained from these investigations fairly well represents the different degrees of protein absorption from diets composed of rice and dal, under varying conditions as regard the quantities of rice consumed.

The figures on which this chart is based will be found in the different tables given in this chapter. They are :—

With 32 ozs. of rice consumed	.	6·55	grms. nitrogen absorbed.
,, 26 ,, ,, ,, ,, (average)	.	7·55	,, ,, ,,
,, 24 ,, ,, ,, ,,	. .	8·00	,, ,, ,,
,, 23 ,, ,, ,, ,,	. .	8·09	,, ,, ,,
,, 20 ,, ,, ,, ,,	. .	8·40	,, ,, ,,
,, 19 ,, ,, ,, ,,	. .	8·47	,, ,, ,,
,, 16 ,, ,, ,, ,,	. .	8·51 (?)	,, ,, ,,

* Chart I.

We have reason to believe that the top of the curve or maximum absorption lies about 18 ozs. of rice per man daily ;—something like what has been introduced in the dotted lines joining 19, 18 and 16 ozs. The marked flattening that begins from 21 ozs., as the curve is traced back with diminishing quantities of rice, shows that we are nearing the limits for a maximum absorption and that those limits lie close to about 18 ozs. of rice. We may, therefore, conclude from the results of these investigations that in a diet of the lower Bengal jail type the optimum amount of rice has been long passed before 26 ozs. per man daily is reached, and that this optimum is about 18 ozs. Consequently any rice in the dietaries in excess of 18 ozs. per man daily is not only useless but actually clogs the absorption of protein, so that the amount of nitrogen undergoing metabolism actually falls. The amount of rice in the dietaries of lower Bengal should not therefore exceed from 18 to 20 ozs. per man daily. A reduction of at least 8 ozs. per man is therefore not only possible but—what is of more importance—is greatly to be desired in the interests of the prisoners : for, by this reduction nitrogenous metabolism is placed on a higher level and, at the same time, the excessive carbohydrates of the diet with their concomitant disabilities are to some extent lessened.

The composite chart we have plotted for the absorption of protein in dietaries containing varying quantities of different dals is derived from the figures given in Table V (*a*) of this chapter. (See Chart II.)

We do not attach anything like the same importance to this chart as to Chart I, for various reasons, the most important being that when the rice of the diet scale is reduced to something approaching proper physiological conditions, the level of nitrogenous absorption is so raised that a reduction in the amount of dal by 1 oz. per man daily, even if it had any effect in decreasing nitrogenous metabolism—the results of all our investigations are opposed to any such effect—would not be a matter of any consequence.

Further, with a reduction in the quantity of rice, less dal will naturally be required for the proper admixture of the ingredients of the diet, to render it palatable and of the desired consistency. When we come to the working out of practical diet scales we shall have other methods of providing absorbable protein, without running any risk of increasing the quantity of dal beyond its physiological limits.

SECTION 4.

4. The effects of varying the components of the diet, *i.e.*, of adding wheat ata, fish or meat.

We have made a large number of observations on the effects of adding wheat ata, fish or meat to the diet, while at the same time decreasing the quantity of rice

or dal as the case may be. The results obtained were very much what we expected. As soon as any of these substances were substituted for rice the percentage of protein absorption showed a sudden rise and the actual protein metabolism became largely increased. As it would not serve any useful purpose to give in full detail all the different experiments carried out, and as all that is to be learned from them can be shown in a few examples, we shall content ourselves by stating as concisely as possible the results of the observations.

We shall take up this part of the work under two heads—

(*a*) Effects of adding wheat ata to the lower Bengal dietaries.

(*b*) Effects of adding an animal protein to the Lower Bengal dietaries.

(*a*) THE EFFECTS OF ADDING WHEAT ATA TO THE RICE AND DAL OF THE ORDINARY DIET.

TABLE VII.

(i) Investigations to determine the degree of nitrogenous metabolism on a diet of the lower Bengal type, when only half the quantity of rice is given and a sufficient quantity of wheat ata is substituted to replace the nitrogen lost by the reduction of rice.

Puri Jail—Ooriyas—four men observed for eight days.

Batch.	Quantity of urine.	Re-action.	Total nitrogen of urine.	N. of rice.	N. of dals.	N. of wheat ata.	N. of vegeta-bles.	Weight.
	C. C.		Grms.	Grms.	Grms.	Grms.	Grms.	Lbs.
Four prisoners, Ooriyas	4,270	Acid	40·56	16·04	25·70	15·13	1·96	111·2
	3,400	„	39·84	16·04	25·70	15·13	1·96	..
	4,260	„	40·76	16·04	25·70	15·13	1·96	..
	3,740	„	38·45	16·04	25·70	15·13	1·96	111
	3,850	„	40·47	16·04	25·70	15·13	1·96	..
	3,690	„	38·17	16·04	25·70	15·13	1·96	..
	3,910	„	41·17	16·04	25·70	15·13	1·96	111·2
	3,940	„	41·57	16·04	25·70	15·13	1·96	111·2

Total intake of nitrogen—		Total output—	
N. of rice . . .	128·32 grms.	N. of urine	323·99 grms.
N. of dals* . . .	205·60 „	·5 grm. daily constant . .	16·00 „
N. of wheat ata . .	121·04 „		
N. of vegetables . .	15·68 „	Total metabolism . . .	339·99 „
		=72·24 per cent. of the nitrogen of the diet,	
Total nitrogen intake .	470·64 „	=10·62 grms. nitrogen per man daily.	

* Arhar and gram dals.

These results should be contrasted with those given in Table III (ii) and (iii) :—

Ordinary Jail diet	49·49 per cent. of N. of diet absorbed.	7·43 grms. daily.
This diet	72·24 ,, ,, ,, ,,	10·63 ,, ,,

That is by giving only one-half of the quantity of rice in the jail diet, and substituting for the other half a sufficient quantity of wheat ata to offer an amount of nitrogen equal to that lost by the reduction of rice, there is an increase in the percentage of protein absorbed from about 50 to over 72 per cent. and an increase in the actual amount of nitrogen undergoing metabolism from 7·4 grms. to 10·52 grms. per man daily. This great increase is due to two factors: the diminution in the quantity of rice by decreasing the bulk of the diet permits, as we have already seen, of an increased protein absorption ; further, the addition of wheat ata is the substitution of a more easily assimilable protein for the protein of rice, so that an increased amount of nitrogen is absorbed from practically an identical nitrogen intake. It is also possible that the change in the type of diet has a favourable influence on protein absorption beyond what would normally be the case were the diet constantly in use. Evidence of this is afforded by the high protein absorption shown by Ooriyas and Bengalis on the addition of wheat ata—the percentage of absorption being on the whole higher than is the case with Beharis on a similar diet but one to which they are accustomed.

(ii) Investigations to determine the degree of nitrogenous metabolism on a diet of the lower Bengal type when one-fourth the quantity of rice and one-sixth the quantity of dal are replaced by their nitrogen equivalent (almost) in the form of wheat ata, *i.e.*—

Rice . . .	20 ozs.	Wheat ata . . .	6 ozs.
Massur dal . .	5 ,,	Vegetables . . .	6 ,,

Four prisoners—Ooriyas—over five consecutive days.

Batch D.	Quantity of urine.	Re-action.	N. of urine.	N. of rice.	N. of massur dal.	N. of wheat ata.	N. of vegeta-ables.	Weight.
	C. C.		Grms.	Grms.	Grms.	Grms.	Grms.	Lbs.
Four prisoners, Ooriyas.	5,330	Acid	34·77	24·68	23·43	12·36	1·88	118·6
	5,800	,,	40·36	24·68	23·43	12·36	1·88	118·6
	6,730	,,	41·14	24·68	23·43	12·36	1·88	118·2
	6,040	,,	38·89	24·68	23·43	12·36	1·88	118·4
	5,570	,,	36·34	24·68	23·43	12·36	1·88	118·5

Total intake—

N. of rice . . .	123·40 grms.
N. of massur dal .	117·15 „
N. of wheat ata .	61·80 „
N. of vegetables .	9·40 „
Total N. of intake .	311·75 „

Total output—

N. of urine	191·50 grms.
·5 grm. constant . . .	10·00 „
Total nitrogenous metabolism	201·50 „

=64·63 per cent. of the nitrogen of the diet,
=10·07 grms. nitrogen per man daily.

Contrast this result with the average protein metabolism on the full Bengal jail diet :—

Full Bengal Jail diet gives	50 per cent. of its N. absorbed	=	7·55 grms. daily.
This diet	64·63 „ „ „ „	=	10·07 „ „

i.e., by decreasing the rice by 6 ozs. and the dal by 1 oz. per man daily and substituting 6 ozs. of wheat ata, we get an increase in the percentage of protein absorption from 50 per cent. to 64·63 per cent. and an actual increase in the protein metabolism from 7·55 grms. to 10·07 grms. per man daily.

Contrasted with the result shown in (i) of this table the relatively greater proportion of rice in this diet—20 ozs. instead of 13 ozs.—has the effect of lowering the relative and actual protein absorption.

In order to solve the problem whether by increasing the wheat ata considerably a better absorption of protein would be obtained, we added to this diet an additional 3 ozs. of wheat ata per man daily.

(iii) Investigations to determine the degree of nitrogenous metabolism on a diet containing a large amount of rice and wheat ata, *i.e.*—

Rice . . .	20 ozs.	Wheat ata . . .	9 ozs.
Massur dal . .	5 „	Vegetables . . .	6 „

Four prisoners—Ooriyas—over five consecutive days.

Batch D.	Quantity of urine.	Re-action.	N. of urine.	N. of rice.	N. of massur dal.	N. of wheat ata.	N. of vegeta-bles.	Weight.
	C. C.		Grms.	Grms.	Grms.	Grms.	Grms.	Lbs.
Four prisoners, Ooriyas .	5,800	Acid	36·56	24·68	23·43	18·54	1·88	119·6
	5,750	„	37·35	24·68	23·43	18·54	1·88	119·8
	5,750	„	34·01	24·68	23·43	18·54	1·88	119·8
	5,860	„	38·78	24·68	23·43	18·54	1·88	119·5
	5,430	„	38·92	24·68	23·43	18·54	1·88	119·6

Total intake—		Total output—	
N. of rice . . .	123·40 grms.	N. of urine	185·62 grms.
N. of massur dal . .	117·15 ,,	·5 grm. daily constant . .	10·00 ,,
N. of wheat ata . .	92·70 ,,		
N. of vegetables . .	9·40 ,,	Total nitrogenous metabolism	195·62 ,,
			=57·09 per cent. of the nitrogen of the diet,
Total N. of intake .	342·65 ,,		= 9·78 grms. of nitrogen per man daily.

The importance of this result is seen when we contrast it with the foregoing.

These two investigations (ii) and (iii), Table VII, were made on the same prisoners and under exactly the same conditions, the only difference being that in (iii) 9 ozs. of wheat ata were given instead of 6 ozs. per man daily. The result is :—

Constants.			Grms. of nitrogen absorbed.	Per cent. nitrogen absorbed.
Rice . . 20 ozs.	+	Wheat ata 6 ozs. .	10·07	64·63
Dal . . 5 ,,				
Vegetables . 6 ,,	+	Wheat ata 9 ozs. .	9·78	57·09

That is, in a diet containing 20 ozs. of rice we actually get a better absorption when 6 ozs. of wheat ata are added than when 9 ozs. are given. So that, with 20 ozs. of rice in the diet, 9 ozs. of wheat ata is beyond the amount from which the maximum absorption can take place. We shall see later, that in the Behari type of diet the rice must be reduced considerably below 20 ozs. in order to get the maximum absorption from a diet containing 9 or 10 ozs. of wheat ata per man daily.

We need hardly again refer to the futility of attempting to obtain the co-efficient of protein absorption of rice, wheat ata, or dal. Thus, in (ii) and (iii) the difference of the nitrogen intake=6·18 grms. is in favour of (iii), whilst the difference in nitrogen absorption is 1·17 grms. in favour of (ii). So that apparently none of the protein of the extra 3 ozs. of wheat is absorbed, *i.e.*, actually less protein is absorbed from a diet containing 9 ozs. of wheat ata than from one containing 6 ozs. when these amounts are given with 20 ozs. of rice, 6 ozs. of vegetables and 5 ozs. of dal.

The explanation is that the large bulk of the rice interferes less with the absorption of a diet containing 6 ozs. of wheat ata than with that of one containing 9 ozs.

(iv) Further evidence of the beneficial effects of a reduction of the quantity of rice and the substitution of a more easily assimilable protein, is afforded by the following observations carried out in the Presidency Jail, Calcutta.

We saw in Table V (ii) from investigations on ten prisoners on a diet of 24 ozs. of Burma rice and 3 ozs. each of massur and mattar dals that 55·39 per cent.

of the nitrogen of the diet was absorbed which meant 8·00 grms. per man daily. Contrast this result with that obtained by reducing the quantity of Burma rice to 18 ozs. per man daily and giving 4·5 ozs. of wheat ata instead.

Ten prisoners observed over five consecutive days.

Batch.	Quantity of urine.	N. of urine.	N. of rice.	N. of wheat ata.	N. of massur dal.	No. of mattar dal.	N. of vegetables.	Weight.
	C. C.	Grms.	Grms.	Grms.	Grms.	Grms.	Grms.	Lbs.
Ten prisoners, Bengalis	21,940	96·87	56·80	27·18	34·26	29·66	4·72	117·6
	24,020	94·65	56·80	27·18	34·26	29·66	4·72	117·8
	21,500	96·69	56·80	27·18	34·26	29·66	4·72	117·8
	18,960	99·84	56·80	27·18	34·26	29·66	4·72	117·5
	17,960	97·10	56·80	27·18	34·26	29·66	4·72	117·5

Total intake of nitrogen—

N. of Burma rice	284·00	grms.
N. of massur dal	171·30	,,
N. of mattar dal	148·30	,,
N. of wheat ata	135·90	,,
N. of vegetables	23·60	,,
Total N. of intake	763·10	,,

Total output—

N. of urine	485·15	grms.
·5 grm. daily constant	25·00	,,
Total nitrogenous metabolism	510·15	,,

=66·85 per cent. of nitrogen of diet,
=10·20 grms. nitrogen per man daily.

That is, by reducing the quantity of rice by 6 ozs. per man daily and substituting for it 4·5 ozs. of wheat ata, there is an increase in the percentage of protein absorption from 55·39 to 66·85 per cent. and an actual increase in nitrogenous metabolism from 8·00 grms. to 10·20 grms. per man daily.

(v) As we had obtained evidence that 6 ozs. of dal was probably beyond the amount from which the maximum absorption was possible, the following observations were made in order to determine the effects of a reduction of the amount of dal from 6 ozs. to 4 ozs. per man daily. The amount of rice was reduced from 26 to 18 ozs.—its nitrogen equivalent being made up by adding 4 ozs. of wheat ata:—

Burma rice	18 ozs.	Wheat ata	4 ozs.
Massur dal	2 ,,	Vegetables	6 ,,
Mattar dal	2 ,,		

Five Bengali prisoners observed during five consecutive days.

BATCH B.	Quantity of urine.	Re-action.	Total N. of urine.	N. of rice.	N. of mattar dal.	N. of mattar dal.	N. of wheat.	N. of vegeta-bles.	Weight.
	C. C.		Grms.	Grms.	Grms.	Grms.	Grms.	Grms.	Lbs.
Three Hindus Two Mahomedans	11,550	Acid	42·76	28·40	11·42	9·86	12·08	2·36	117·5
	10,950	„	44·37	28·40	11·42	9·86	12·08	2·36	117·2
	10,090	„	37·74	28·40	11·42	9·86	12·08	2·36	117·3
	10,680	„	40·47	28·40	11·42	9·86	12·08	2·36	117·5
	10,670	„	38·28	28·40	11·42	9·86	12·08	2·36	117·5

Total intake—

N. of rice . . .	142·00 grms.
N. of massur dal .	57·10 „
N. of mottar dal .	49·40 „
N. of wheat ata .	60·40 „
N. of vegetables .	11·80 „
Total N. intake .	=320·60 „

Output—

N. of urine . . .	=203·62 grms.
·5 grm. constant . .	·250 „
Total metabolism . .	=216·12 „

=67·41 per cent. of N. of diet,
=8·64 grms. of N. per day per man.

Taken in conjunction with the results obtained from the full jail diet the great superiority of this type of diet is very evident :—

	Per cent. absorption.	Grms. of nitrogen per man daily.
Ordinary jail diet —26 ozs. rice, 6 ozs. dal . . .	50·00	7·55
This diet— 18 „ „ 4 „ „ . 4 „ wheat ata	67·41	8·64

When wheat ata was substituted for part of the rice or dal or both many other results were obtained and all showed the beneficial effects of a reduction to 18 ozs. of the quantity of rice in the diet, when its nitrogen was partly or wholly replaced by protein derived from wheat ata. The observations also corroborated the evidence already brought forward that the 6 ozs. of dal in the ordinary jail diet can be reduced with satisfactory results, so far as the protein metabolism of the prisoners is concerned. Even in the case of gram dal, which is the poorest in nitrogen and, as we have already intimated, probably the most difficult of assimilation, a reduction of one ounce per man daily can easily be made—when the rice is reduced to 18 ozs. and 4 ozs. of wheat ata are added to the diet—and a

protein absorption be obtained much superior to that possible with the ordinary jail diet.

Thus on a diet consisting of—

Burma rice	18 ozs.	Wheat ata	4 ozs.
Gram dal	5 ,,	Vegetables	6 ,,

The average metabolism was practically 8·50 grms. of nitrogen per day.

From these observations it is evident that by a very simple change in the diet, much better results can be obtained than is possible from the lower Bengal dietaries as at present constituted.

The changes foreshadowed by these investigations would be :—

(*a*) A diminution in the quantity of rice from the ordinary 26 ozs. to the amount from which a maximum protein absorption is possible—about 18 ozs.

(*b*) A diminution in the amount of dal by two ounces per man daily.

(*c*) An addition of a small amount of wheat ata to the diet—the amount need not exceed 4 ozs. per man daily.

The effects of these changes would be to place the prisoners on a higher level of protein metabolism by increasing very markedly the percentage of protein absorption from the diet and decreasing by at least 50 per cent. the amount of nitrogenous residue left in the intestinal canal thus obviating one of the worst defects of the present diet. At the same time the diminution of rice by 8 ozs. per man daily will help to bring the carbohydrate element and the total caloric value of the diet within the bounds of physiological limits, and assist in reducing the excessive fermentation in the intestines. We shall have to discuss the framing of diet scales later in the light of investigations carried out over a considerable period on diets which have been based on the observations just recorded, and on some others in which an animal protein replaced part of the nitrogen of rice. To a consideration of the latter we shall now pass.

(*b*) The effects of adding an animal protein to a diet of rice and dal—Lower Bengal jail type.

TABLE VIII.

From investigations carried out in which an animal protein was introduced into the diet, it was again very evident that the more the rice was decreased the higher became the percentage of protein absorbed.

The substitution of animal food material for the dal of the diet made a great difference, but not nearly so much as its substitution for rice.

The following series of results bring out these points very clearly :—

(i) Substitution of nitrogen derived from goat's flesh for half the nitrogen of arhar dal, full diet of 26 ozs. of rice.

Four prisoners—all Ooriyas—urine of prisoners pooled.

[The table also shows the gradual effect of the change in diet, two days being necessary before the maximum absorption takes place. The last three days only are accepted.]

BATCH.	Total quantity of urine.	Reaction.	N. in urine.	Weight.	N. in rice.	N. in arhar dal.	N. in goat's flesh.	N. in vegetables.
	C. C.		Grms.	Lbs.	Grms.	Grms.	Grms.	Grms.
Four prisoners, Ooriyas .	5,600	Acid	27·71	108·2	32·08	12·85	12·95	1·96
	6,000	,,	34·94	108·5	32·08	12·85	12·95	1·96
	5,700	,,	36·75	108·2	32·08	12·85	12·95	1·96
	5,280	,,	37·32	108·2	32·08	12·85	12·95	1·96
	4,440	,,	37·23	108·2	32·08	12·85	12·95	1·96

Total intake—

N. of rice . .	96·24	grms.
,, of dal . .	38·55	,,
,, of goat's flesh .	38·85	,,
,, of vegetables .	5·88	,,
Total N. intake .	=179·52	,,

Output—

N. in urine	=111·30	grms.
Constant ·5 grm. . .	= 6·00	,,
Total N. metabolism . .	=117·30	,,
	= 65·34 per cent. of N. of diet,	
	= 9·77 grms. of N. per day per man.	

Contrasted with the result given on Table III (ii), where the same five men were on the full jail diet of 26 ozs. of rice and 6 ozs. of arhar dal, we see that by the substitution for half the ordinary amount of arhar dal of its nitrogen equivalent in the form of goat's flesh we get :—

	Per cent. of protein absorbed.	Grms. of nitrogen per man daily.
26 ozs. rice, 6 ozs. arhar dal . . .	49·78	7·43
26 ,, ,, 3 ,, ,, ,, 4½ ozs. flesh. .	65·34	9·77

(ii) Substitution of nitrogen, derived from goat's flesh and fish, in quantities considerably less than sufficient to make up for the diminution in the nitrogen due to decreasing the rice of the ordinary diet by a half—the full amount of nitrogen from gram dal given, 7 ozs.

Four Ooriya prisoners under observation for six consecutive days.

BATCH.	Total quantity of urine	Reaction.	N. in urine.	Weight.	N. in rice.	N. in dal.	N. in fish.	N. in goat's flesh.	N. in Vegetables.
	C. C.		Grms.	Lbs.	Grms.	Grms.	Grms.	Grms.	Grms.
Four prisoners, Ooriyas.	5,965	Acid	38·22	108·2	16·04	25·74	6·52	7·20	1·96
	4,450	,,	37·31	108·2	16·04	25·74	6·52	7·20	1·96
	4,760	,,	47·98	108·0	16·04	25·74	6·52	7·20	1·96
	5,540	,,	50·10	107·8	16·04	25·74	6·52	7·20	1·96
	4,930	,,	39·73	108·2	16·04	25·74	6·52	7·20	1·96
	4,820	,,	45·92	108·2	16·04	25·74	6·52	7·20	1·96

Total intake—

N. of rice	96·24	grms.
,, ,, dal	154·44	,,
,, ,, fish	39·12	,,
,, ,, goat's flesh	43·20	,,
,, ,, vegetables	11·76	,,
Total N. of intake =	344·76	,,

Output—

N. of urine	= 259·26	grms.
Constant ·5 grm.	= 12·00	,,
Total N. metabolism	= 271·26	,,

= 78·68 per cent. total N. of diet,
= 11·30 grms. of N. per day per man.

Contrasted with the results given on Table III (iii), where the same five men were on the full jail diet 26 ozs. of rice and 7 ozs. of gram dal, we see that by the substitution of considerably less than its nitrogen equivalent in the form of fish and goat's flesh for half the rice of the ordinary diet we get:—

	Per cent. of protein absorbed.	Grms. nitrogen per man daily.
Ordinary diet—		
26 ozs. rice, 7 ozs. gram dal	49·20	7·35
13 ozs. rice, 7 ozs. gram dal { 3 ozs. fish, 2½ ozs. goat's flesh }	78·68	11·30

Contrasting (i) and (ii) of this table we see how very much greater the effect on protein absorption is when practically the same amount of animal protein replaces part of the rice of the diet than when it replaces the dal. This affords still further evidence of the beneficial effects of a rednction of the huge quantity of rice in the dietaries of Bengal jails.

(i) and (ii) contrasted :—

N. of rice.	N. of dal.	N. of animal protein.	Per cent. of protein absorbed.	Grms. of nitrogen per man daily.
Grms.	Grms.	Grms.		
32·08	12·85	12·95	65·34	9·77
16·04	25·74	13·72	78·68	11·30

(iii) The effects of substitution of practically the exact nitrogen equivalent of half the dal by wheat ata, and considerably less than the nitrogen equivalent of half the rice by protein derived from fish :—

Diet A.—Rice . . . 13 ozs. | Fish . . . . 6 ozs.
Arhar dal . . . 3 „ | Wheat ata . . . 6·5 „
Vegetables . . . 6 ozs.

[These observations show the gradual effect of the new diet, two days being required before nitrogenous metabolism became constant at the higher level obtained, with the more assimilable protein of wheat ata and fish.]

Four prisoners—Ooriyas—observed for three days.

Batch.	Total quantity of urine.	Reaction.	Total N. of urine.	Weight	N. in rice.	N. in arhar dal.	N. in ata.	N. in fish.	N. in vegetables.
	C. C.		Grms.	Lbs.	Grms.	Grms.	Grms.	Grms.	Grms.
Four prisoners, Ooriyas.	5,080	Acid.	27·70	..	16·04	12·85	12·36	13·04	1·96
	5,000	„	36·65	98·2	16·04	12 85	12·36	13·04	1·96
	5,000	„	45·85	98·2	16·04	12·85	12·36	13·04	1·96
	4,650	„	46·59	98·2	16·04	12·85	12·36	13·04	1·96
	4,620	„	44·99	98·2	16·04	12·85	12·36	13·04	1·96

Total intake—
N. in rice . . . 48·12 grms.
„ „ dal . . . 37·55 „
„ „ ata . . . 37·08 „
„ „ fish . . . 39·12 „
„ „ vegetables. . . 5·88 „

Total N. of intake . = 167·75 „

Output—
N. in urine . . . 137·43 grms.
Constant ·5 grm. . . 6·00 „

Total N. metabolism . = 143·43 „
= 85·50 per cent. of total N. of diet,
= 11·95 grms. per day per man.

That is, with a diet of the above type we obtain an absorption of protein that compares very favourably with that got from European types of dietaries—twelve out of the fourteen grms. of nitrogen offered per man daily being absorbed. So that the Bengali is quite able to assimilate and make use of protein when this is offered him in a form easy of absorption.

(iv) Practically the same diet as in (iii) except that gram dal replaces arhar dal while the nitrogen from fish is somewhat less, *i.e.*—

Diet B.—Rice . . . . 13 ozs. | Fish . . . . 5·2 ozs.
Gram dal . . . 3 „ | Wheat ata . . . 6·5 „
Vegetables . . . 6 ozs.

Batch.	Total quantity of urine	Re-action.	Total N. of urine.	Weight.	N. in rice.	N. in gram dal.	N. in ata.	N. in fish.	N. in Vege-tables.
	C. C.		Grms.	Lbs.	Grms.	Grms.	Grms.	Grms.	Grms.
Four prisoners	5,570	Acid	39·04	98·8	16·04	12·87	12·36	11·41	1·96
	5,630	,,	39·51	98·8	16 04	2·87	12·36	11·41	1·96
	4,220	,,	39·30	98·6	16·04	12·87	12·36	11·41	1·96
	5,820	,,	38·74	98·7	16·04	12·87	12·36	11·41	1·96
	4,700	,,	40·36	98·8	16·04	12·87	12·36	11·41	1·96

Total intake—

N. in rice	80·02 grms.
,, ,, arhar dal	64·35 ,,
,, ,, ata	61·80 ,,
,, ,, fish	57·05 ,,
,, ,, vegetables	9·80 ,,
otal N. of intake	=273·20 ,,

Total output—

N. of urine	196·95 grms.
·5 grm. daily constant	10·00 ,,
Total nitrogenous metabolism	206·95 ,,
	= 75·71 per cent. of nitrogen of diet,
	= 10·35 grms. of nitrogen per man daily.

If we assume in these results (iii) and (iv) that an identical amount of nitrogen is absorbed from 12·85 grms. of arhar dal and 12·87 grms. of gram dal, then the difference in the daily quantity of nitrogenous metabolism must be due to the difference in the nitrogen intake of fish.

Difference in nitrogen intake of fish between (iii) and (iv)	=65·20—57·05 grms.
	= 8·15 ,,
Difference in amount of nitrogenous metabolism (iii) and (iv)	=59·75—51·05 ,,
	= 8·00 ,,

which would mean that 8·15 grammes of nitrogen as fish gives an increased nitrogenous metabolism of 8 grms. or that practically 100 per cent. is absorbed; but we have shown that when the protein of arhar dal and gram dal is offered in equal quantities, the protein of gram dal is not quite so well absorbed as that of arhar dal—see synopsis of Table III—so that, making allowance for this slight difference, it would mean that 96·8 per cent. of the nitrogen offered in the extra fish was absorbed, a result very closely approaching those obtained by European and American workers.

But, as we have already pointed out, it is only possible to show that over 95 per cent. of the protein of fish is absorbed when the bulk of the jail diet is very greatly diminished. When the diet is at all bulky the protein absorption from fish or animal diet appears much lower than 95 per cent.: this is most probably not due to less being absorbed, but to the fact that the system being able to satisfy its requirements easily from fish or the animal diet given, less protein is absorbed from the bulky part of the diet than would otherwise be the case. In all probability also the bulkiness of the diet interferes with the protein absorption from animal food-

stuffs, just as we have seen it does in the case of vegetable materials. Whatever the true explanation may be there is no doubt that when the rice of the diet is excessive in amount, the addition of an animal protein has not the same relative effect in increasing nitrogenous metabolism as when the quantity of rice is low. Now this cannot be due to the excessive carbohydrate element, when the quantity of rice is large, sparing protein, because we find exactly the same results when the carbohydrates are kept constant; and we have good reason to suppose that when the carbohydrate element of a diet is such as supplied by the ordinary Bengal jail standard, a very large part of it is never made use of in the body, but is either broken down by fermentation or passed out unchanged.

The influence of the bulkiness of a diet on the apparent amount of nitrogen absorbed from an animal protein is clearly brought out in the following investigations :—

(v) In Table V (iii) we saw that on a diet composed of—

Rice . . . . 20 ozs.
Massur dal . . 3 ,,
Mottar dal . . 3 ,,
Vegetables . . 6 ,,

there was a nitrogenous metabolism of 8·40 grms. of nitrogen per man daily.

Now add 6 ozs. of fish to this diet and we get :—

Four prisoners observed for five consecutive days.

Batch.	Quantity of urine.	Re-action.	N. of urine.	N. of rice.	N. of massur dal.	N. of fish.	N. of Vege-tables.	Weight.
	C. C.		Grms.	Grms.	Grms.	Grms.	Grms.	Lbs.
Four prisoners	5,555	Acid	40·48	24·68	28·12	13·04	1·88	113·9
	4,470	,,	40·67	24·68	28·12	13·04	1·88	114·2
	6,150	,,	46·58	24·68	28·12	13·04	1·88	113·4
	5,110	,,	41·49	24·68	28·12	13·04	1·88	113·6
	4,300	,,	39·47	24·68	28·12	13·04	1·88	113·9

Total intake—
N. of rice . . 123·40 grms.
,, ,, massur dal . 140·60 ,,
,, ,, fish . . 65·20 ,,
,, ,, vegetables . 9·40 ,,

Total N. of intake = 338·60 ,,
Difference in nitrogen intake due to added fish = 13·04 ,,

Total output—
N. of urine . . . . 208·69 grms.
·5 grm. constant . . . 10·00 ,,

Total N. metabolised . . . 218·69 ,,
= 64·58 per cent. of diet,
= 10·93 grms. N. per day per man.
Difference in nitrogenous metabolism . . . = 10·12 grms.

which would apparently mean that 13·04 grms. of nitrogen given in fish increases the nitrogenous metabolism by 10·12 grms.

This would be an absorption of 77·6 per cent. of the protein of fish; but we have already seen from investigations (iii) and (iv) of this Table, that 96·8 per cent. of the nitrogen of fish is absorbed when the rice is reduced to 13 ozs. per man daily; there must, therefore, be some influence at work to cause this great variation. It cannot be a difference in the carbohydrate element as this is identical in the two diets contrasted in (v); so that by exclusion it can only be the difference in the bulkiness of the diet in (iii) and (iv)—where rice is given in quantities of 13 ozs., compared with its bulk in (v)—where 20 ozs. of rice per man daily are given.

(vi) Further evidence that the addition of an animal protein to a diet containing a large amount of rice has nothing like it proper influence in raising the level of nitrogenous metabolism, is afforded by the following investigations:—

Rice	20 ozs.	same diet as in (v) with the addition of 3 ozs. more fish.
Massur dal	6 „	
Fish	9 „	
Vegetables	6 „	

Four prisoners observed for five consecutive days.

Batch C.	Quantity of urine.	Re-action.	N. of urine.	N. of rice.	N. of massur dal.	N. of fish.	N. of vege-tables.	Weight.
	C. C.		Grms.	Grms.	Grms.	Grms.	Grms.	Lbs.
Four prisoners, Ooriyas	4,230	Acid	44·14	24·68	28·12	19·56	1·88	114·8
	4,900	„	42·60	24·68	28·12	19·56	1·88	115·0
	5,400	„	43·84	24·68	28·12	19·56	1·88	115·0
	5,025	„	45·51	24·68	28·12	19·56	1·88	114·6
	4,380	„	47·41	24·68	28·12	19·56	1·88	114·8

Total intake—

N. of rice	123·40 grms.
„ „ massur dal	140·60 „
„ „ fish	97·80 „
„ „ vegetables	9·40 „
Total N. of intake	371·20 „

Total output—

N. of urine	223·50 grms.
·5 grm. constant	10·00 „
Total N. metabolised	233·50 „
	=62·9 per cent. of N. of diet,
	= 11·7 grms. N. per day per man.

That is, contrasting the results in (iii), (iv), (v) and (vi) of this table we get:—

Constant.				Nitrogen undergoing metabolism. Grms.
Rice	13 ozs.	+	(a) Fish 3·26 grms. N=6 ozs.	11·95 per man daily.
Arhar dal	3 „		(b) „ 2·85 „ N=5·2 ozs.	10·35 „ „ „
Wheat ata	6·5 „			
Vegetables	6 „			

which means the absorption of 96·8 per cent. of the nitrogen of fish.

			Nitrogen undergoing metabolism. Grms.
Rice . . 20 ozs.	+	(α) *Nil* grms. N.	8·40 daily.
Massur dal . 6 „		(β) Fish 4·89 grms. N. =9 ozs. .	11·70 „
Vegetables . 6 „		(γ) „ 3·26 „ N. =6 „ .	10·93 „

which means the absorption between (α) and (γ) of 77·6 per cent. of the nitrogen of fish and between (α) and (β) of 67·5 per cent. of the nitrogen of the fish. So that an increase in the quantity of fish in a diet would appear to cause a decreased percentage of its protein absorption. This relative decrease is, however, not due entirely to less of the nitrogen of fish being absorbed but, in all probability, is brought about by the physiological requirements being satisfied by the animal protein *plus* a certain amount from the other constituents. Therefore, an increase in the animal protein will entail less nitrogen being required from the other constituents, and thus an apparently low protein absorption from fish will occur.

In whatever way this is brought about, the fact remains that unless the bulk of a diet is such that the stomach and intestinal tract can deal with it effectively, the maximum percentage of protein absorption cannot take place. This in itself is a strong argument for a decrease in the bulk of the diet and, *à fortiori*, of its rice content.

(vii) The effect on nitrogenous metabolism of replacing one-third of the protein of rice by nitrogen in the form of wheat ata, and one-third of the protein of dal by nitrogen in the form of goat's flesh, *i.e.*,—

Rice	18 ozs.	Goat's flesh . . .	3·2 ozs.
Massur and mattar dals .	4 „	Vegetables . . .	6 „
Wheat ata . . .	4·5 „		

Five Bengali prisoners observed over ten days.

Batch D.	Quantity of urine.	Re-action.	N. of urine.	N. of rice.	N. of dals.	N. of wheat ata.	N. of goat's flesh.	N. of vege-tables.	Weight.
	C. C.		Grms.	Grms.	Grms.	Grms.	Grms.	Grms.	Lbs.
Five prisoners, Bengalis.	9,370	Acid	46·17	28·40	21·28	13·59	10·50	2·36	119·8
	9,930	„	46·15	28·40	21·28	13·59	10·50	2·36	119·7
	9,800	„	47·16	28·40	21·28	13·59	10·50	2·36	119·8
	10,830	„	46·93	28·40	21·28	13·59	10·50	2·36	119·9
	9,970	„	44·24	28·40	21·28	13·59	10·50	2·36	120·1
	10,360	„	45·68	28·40	21·28	13·59	10·50	2·36	120·0
	8,390	„	49·62	28·40	21·28	13·59	10·50	2·36	119·9
	9,900	„	52·83	28·40	21·28	13·59	10·59	2·36	111·9
	9,310	„	49·18	28·40	21·28	13·59	10·59	2·36	119·8
	8,500	„	52·00	28·40	21·28	13·59	10·59	2·36	119·8

Total intake—

N. of rice . .	284·00 grms.
„ „ dals . .	212·80 „
„ „ wheat ata .	135·90 „
„ „ goat's flesh .	105·00 „
„ „ vegetables .	23·60 „
Total N. of intake .	=761·30 „

Output—

N. of urine . . .	479·96 grms.
·5 grm. constant . .	25·00 „

Total nitrogenous metabolism = 504·96 „
= 66·33 per cent. of N. of diet.
= 10·09 grms. N. per day.

(viii) In connection with (vii) we give the result from exactly the same diet but with almost the same amount of nitrogen derived from fish replacing that from goat's flesh. 3·4 ozs. of fish replacing 3·2 ozs. of goat's flesh.

Five Bengali prisoners over ten days' observation.

Batch C.	Quantity of urine.	Re-action.	Total N. of urine.	N. of rice.	N. of dals.	N. of wheat ata.	N. of fish.	N. of vege-tables.	Weight.
	C. C.		Grms.	Grms.	Grms.	Grms.	Grms.	Grms.	Lbs.
Five prisoners, Bengalis.	8,880	Acid	45·75	28·40	21·28	13·59	10·00	2·36	124·8
	8,930	„	48·13	28·40	21·28	13·59	10·00	2·36	124·8
	9,940	„	48·34	28·40	21·28	13·59	10·00	2·36	125·2
	8,920	„	46·64	28·40	21·28	13·59	10·00	2·36	125·4
	9,440	„	46·62	28·40	21·28	13·59	10·00	2·36	125·3
	7,300	„	46 19	28·40	21·28	13·59	10·00	2·36	125·3
	6,290	„	50 37	28·40	21·28	13·59	10·00	2·36	125·0
	7,320	„	53 28	28·40	21·28	13·59	10·00	2·36	124·8
	8,200	„	56·18	28·40	21·28	13·59	10·00	2·36	124·9
	7,540	„	45·17	28·40	21·28	13·59	10·00	2·36	124·8

Total intake—

N. in rice . . .	284·00 grms.
„ dal . . .	212·80 „
„ wheat ata . .	135·90 „
„ fish . .	100·00 „
„ vegetables . .	23·60 „
Total N. of intake .	=756·30 „

Total output—

N. of urine . . .	486·67 grms.
·5 grm. constant . .	25·00 „

Total nitrogenous metabolism = 511·67 „
= 67·65 per cent. of the nitrogen of the diet.
= 10·23 grms. nitrogen per man daily.

Contrasting (vii) and (viii) we see that there is a difference of 5 grms. of nitrogen in the intake in favour of the diet containing goat's flesh, yet there is almost seven grammes of nitrogen better metabolism from the diet containing fish, so that on the whole, fish is slightly more easily absorbed than goat's flesh, but the difference is very small—only 0·14 grm. per man daily.

Taken in conjunction with Table VIII (*v*) it affords further evidence of the slight effect of the addition of an animal protein in raising the level of nitrogenous metabolism, when the diet is bulky and made up of vegetable matter.

Thus in a diet almost exactly similar but containing no goat's flesh or fish we find a nitrogenous metabolism of 9·51 grms. daily; whereas the addition of 2 grammes of nitrogen from fish or 2·1 grms. of nitrogen from goat's flesh only increases the nitrogenous metabolism by 0·71 and 0·58 grm. per man daily.

(ix) We shall conclude this part of the enquiry with three sets of observations in which the rice and dal were constant and reduced—the rice to 18 ozs., the dal to 4 ozs. per man daily; the nitrogenous equivalent for the reduction in rice was made up in different ways. Thus:—

CONSTANT.			
Burma rice	18 ozs.	+	Wheat ata 4 ozs. . =Diet I.
Mattar and massur dals	4 ,,		,, ,, 2·4 ozs. + goat's flesh 2 ozs. =Diet II.
Vegetables	6 ,,		,, ,, 2·4 ozs. + fish 3 ozs. =Diet III.

Diet I.

Five prisoners observed for five days.

BATCH.	Quantity of urine.	Re-action.	Total N. of urine.	N. of rice.	N. of dals.	N. of wheat ata.	N. of vege-tables.	Weight.
	C. C.		Grms.	Grms.	Grms.	Grms.	Grms.	Lbs.
Five prisoners, Bengalis	11,550	Acid	42·76	28·40	21·28	12·08	2·36	117·5
	10,950	,,	44·37	28·40	21·28	12·08	2·36	117·2
	10,090	,,	37·74	28·40	21·28	12·08	2·36	117·3
	10,680	,,	40·47	28·40	21·28	12·08	2·36	117·5
	10,670	,,	38·28	28·40	21·28	12·08	2·36	117·5

Total nitrogen of intake—

N. of rice . . .	142·00 grms.
,, dals . . .	106·40 ,,
,, wheat ata . .	60·40 ,,
,, vegetables . .	11·80 ,,
Total nitrogen intake— .	320·60 ,,

Total output—

N. of urine . . .	203·62 grms.
·5 grm. daily constant .	12·50 ,,

Total nitrogenous metabolism 216·12 ,,
=67·41 per cent. of nitrogen of the diet.
= 8·64 grms. nitrogen per man daily.

i.e., when the nitrogen lost by reducing the rice is replaced by nitrogen in the form of wheat ata 67·41 per cent. of the nitrogen of the diet is absorbed, or 8·64 grms. of nitrogen per man daily.

Diet II.

Five prisoners observed for five days.

Batch D.	Quantity of urine.	Re-action.	N. of urine.	N. of rice.	N. of dals.	N. of wheat.	N. of goat's flesh.	N. of vege-tables.	Weight.
	C. C.		Grms.	Grms.	Grms.	Grms.	Grms.	Grms.	Lbs.
Two Hindus . Three Mahomedans	11,110	Acid	46·78	28·40	21·28	6·79	6·56	2·36	118·2
	11,830	,,	44·85	28·40	21·28	6·79	6·56	2·36	118·0
	9,630	,,	44·49	28·40	21·28	6·79	6·56	2·36	118·4
	12,560	,,	46·24	28·40	21·28	6·79	6·56	2·36	118·4
	10,620	,,	44·52	28·40	21·28	6·79	6·56	2·36	118·2

Total intake—

N. of rice . . .	142·00 grms.
,, dals . . .	106·40 ,,
,, wheat ata . .	33·95 ,,
,, goat's flesh . .	33·80 ,,
,, vegetables . .	11·80 ,,
Total N. of intake .	.=327·95 ,,

Output—

N. of urine . . .	226·88 grms.
·5 grm. constant . .	12·50 ,,
Total N. metabolism .	.=239·38 ,,
	= 72·99 per cent. of N. of diet,
	= 9·57 grms. N. per day per man.

Contrasted with the result shown in Diet I, in this diet the deficiency in nitrogen from rice is made up by almost equal amounts of nitrogen from wheat ata and goat's flesh, instead of, as in Diet I, entirely by wheat ata. The result is that there is a much better absorption from Diet II, showing that the proteins of wheat ata and goat's flesh even when offered in these small amounts are very differently absorbable.

Diet III.

Five Bengali prisoners over five consecutive days.

Batch C.	Quantity of urine.	Total N. of urine.	N. of rice.	N. of dals.	N. of wheat ata.	N. of fish.	N. of vege-tables.	Weight.
	C. C.	Grms.	Grms.	Grms.	Grms.	Grms.	Grms.	Lbs.
Two Hindus . . . Three Mahomedans . .	8,000	47·82	28·40	21·28	6·79	8·39	2·36	123·9
	9,370	50·24	28·40	21·28	6·79	8·39	2·36	123·8
	8,260	43·48	28·40	21·28	6·79	8·39	2·36	124
	9,160	46·16	28·40	21·28	6·79	8·39	2·36	123·8
	8,470	46·95	28·40	21·28	6·79	8·39	2·36	123·9

Total intake—		Output—	
N. of rice . . .	142·00 grms.	N. of urine . . .	234·65 grms.
„ dal . . .	106·40 „	·5 grm. constant . .	12·50 „
„ wheat ata . .	33·95 „		
„ fish . . .	41·95 „	Total N. metabolism . .	247·15 „
„ vegetables .	11·80 „	= 73·54 per cent. of N. of diet,	
		= 9·88 grms. N. per day per man.	
Total N. of intake . .	336·10 „		

Now we have already seen that the protein of goat's flesh and that of fish are practically equally absorbable ; therefore, by contrasting the results of Diet II and III we can find the percentage of protein absorption of fish and goat's flesh in diets of this type.

Thus the difference in nitrogen intake—all due to nitrogen of fish = 8·15 grms.

The difference in the amount of nitrogenous absorption between diets II and III = 7·77 grms.

Therefore 8·15 grms. of nitrogen of goat's flesh or fish show an absorption of 7·77 grms. or 95·3 per cent.

It will be noticed in these investigations that where a normal (European) absorption of the protein of the animal food is obtained, the bulk of the diet is very much reduced from the ordinary jail standard.

Summary of Section 4.

This concludes the investigations so far as this section, dealing with the effects of varying the components by adding wheat ata or an animal protein, is concerned.

It will be evident from the observations recorded in Tables VII and VIII that very good results as regards nitrogenous absorption and metabolism can be obtained by the addition of wheat ata or an animal protein—particularly when the rice or dal or both rice and dal are decreased to nearly the proper limits.

In Tables VII and VIII we may exclude in the present summary all investigations where the full 26 ozs. of rice formed part of the diet or where the rice was reduced to one-half that quantity. The results obtained with these amounts, while very instructive in demonstrating the retarding influence of the full amount of rice on the protein absorption from a diet containing it, or in demonstrating the opposite in the case of diets in which the rice is reduced to 13 ozs., are outside the limits of the quantities of rice necessary in diet scales framed for a rice-eating people. The full amount of 26 ozs. we have ample evidence is far too much and is not only useless but actually harmful as regards protein absorption ; the smaller amount of 13 ozs. is perhaps too low for a people accustomed to consume fairly large quantities of rice.

We have already seen in Section III of this chapter that by decreasing the amount of rice by 8 ozs. or so per man daily, a very much better absorption of the protein of the diet is rendered possible. The questions would, therefore. arise in advocating a change in the jail dietaries—would this not be sufficient, or is it necessary to seek further for a better type of diet? There does not appear to be any doubt but that this reduction would do all that is necessary, *viz.*, permit of a better protein absorption, and relieve the diet of some of its unnecessarily large carbohydrate element.

It is generally admitted that the average amount of rice consumed by the working people is 16 ozs. per head daily, and that the dal taken with the meals is much below 6 ozs., so that the prisoner is better fed than the working population of the country. We have, further, direct evidence that the prisoner's protein metabolism is on a higher level than obtains in students, servants, etc., living on dietaries of their own choosing.* It would, therefore, be no hardship, but on the contrary a dietetic gain, for a member of the working population to be put on a jail diet composed of 18 ozs. of rice and 6 ozs. of dal, or even 5 ozs. of dal. We have no desire to enter into a discussion of the question whether jail diets should be penal; we may say in passing that such a thing is almost an impossibility with diets founded on the food-stuffs in use in Bengal, for the scale of living is so low amongst the great mass of the people that, short of starvation, it would be almost impossible to frame dietaries for prisoners that would not be superior to those on which a large proportion of the classes from which criminals are drawn already exist. We are only concerned with the physiological side of the problem and with the nutritive value of the dietaries—to see that the prisoner's food is given in such quantities that a maximum good may result, and that he may be maintained in health. If we can so arrange the form and quantities of the food materials that these conditions are fulfilled we shall, at the same time, perform our duty to the State by ensuring the greatest economy in the dieting of the prisoner.

Looking at the problem entirely from a physiological point of view—the framing of a diet, limited to rice and dal, that will provide a sufficiency of the actual proximate principles, given in such quantities as will ensure their absorption to a maximum extent—we have no hesitation in stating that a diet composed of—

Rice 18 ozs.	with the ordinary extras
Dals 5 or 6 ozs.	

is much superior to the present scale, not only as regards its physiological aspects but also as regards the maintenance of the health of the prisoners. When rice and dal are combined in these amounts the intestinal tract is able to absorb the nitrogenous elements to a maximum extent and, at the same time, it is relieved

* Scientific Memoirs, No. 34.

from having to deal with the great mass presented by the ordinary jail diet. The carbohydrate element offered even by this reduced scale is more than sufficient to meet the daily requirements, for fuel to maintain body heat and as a source for the energy of muscular contraction.

Further, it is superior to the diet available to the great bulk of the population of lower Bengal, and fulfils the conditions laid down by Major Macnamara, I.M.S.,* "the public obligations towards a prisoner are fully discharged as regards food, when he is given a sufficiency to maintain him in health, though this amount does not necessarily satisfy his craving or capacity."

If, therefore, it is considered advisable to limit the jail dietaries to the food materials rice and dal, we strongly recommend a reduction to at most 20 ozs. of rice with 5 ozs. of dal or 18 ozs. of rice with 6 ozs. of dal.

From the results of the investigations recorded in section (4) it would seem advisable to consider the question of the addition of wheat ata or an animal protein to the lower Bengal scales. While it would not appear to be absolutely necessary to add either of these food materials, the fact that, by giving a very small amount of one of these more easily assimilable forms of protein, we can place the nitrogenous metabolism of the prisoner on a higher scale, and, therefore, in all probability increase his power of resistance to disease, must be looked on as so much gain—particularly so, as this can be done without increasing the cost.

The following collation of the results of observations in which an animal protein or protein from wheat ata was substituted for part of the protein of the ordinary Bengal jail dietary, shows how the addition of an assimilable protein may best be carried out, and what its effects on protein metabolism are :—

Result extracted from Tables VII and VIII.

Constants.	Varying materials.	Per cent. of nitrogen absorbed from diet.	Grms. of nitrogen per man daily.
1 { Rice 20 ozs. Dals 6 " }	Fish 6 ozs.	64·58	10·93
	" 9 "	62·90	11·70
2 { Rice 20 ozs. Dals 5 " } +	Wheat ata 6 ozs.	64·63	10·07
	" " 9 "	57·09	9·78
	" " 4 "†	68·01	8·87
3 { Rice 18 ozs. Dals 6 " } +	Wheat ata 4½ ozs.	66·85	10·20

* Notes on Indian Jail Dietaries. Major Macnamara, I.M.S., 1906.

† The dal given in this observation was 5 ozs. of gram dal, which is about equal to 4 ozs. of any other dal.

Results extracted from Table VII and VIII—*contd.*

Constants.		Varying materials.	Per cent. of nitrogen absorbed from diet.	Grms. of nitrogen per man daily.
4 {Rice 18 ozs. Dals 4 „}	+	Wheat ata 4 ozs.	67·41	8·64
		„ „ $4\frac{1}{2}$ „ + goat's flesh 3·2 ozs.	66·33	10·09
		„ „ $4\frac{1}{2}$ ozs. + fish 3·4 ozs.	67·67	10·23
		„ „ 2·4 ozs.+goat's flesh 2 ozs.	72·99	9·57
		„ „ 2·4 ozs.+fish 3 ozs.	73·54	9·88
Contrasted with average for ordinary diet.				
Rice 26 ozs. Dals 6 „	..	*Nil*	50·50	7·55

It is evident that with any of these types of diet we get a much better absorption than with the ordinary jail diet; there must, therefore, be a proportionally smaller residue for the intestines to deal with, and so much less opportunity for intestinal putrefaction and fermentation. We are not concerned with the question of vegetarianism nor with the degree of nitrogenous metabolism supposed to be most beneficial to health; what we are desirous of doing is to arrange the constituents and the quantities of those constituents in such a manner that a maximum effect will be obtained, thus entailing a minimum amount of waste and an economical dieting of jails by the State.

With this object in view and ever bearing in mind its beneficial effects, so far as can be at present judged on the health of the prisoner, we would recommend that, in case it were deemed advisable to enlarge the list of the constituents of lower Bengal jail diets, a reduction in both rice and dal be made with an addition of wheat ata or—in certain prisons, where fish is easily and cheaply procurable—an interchangeable quantity of fish. The type of diet that would appear to give the best results and leave the least residue would be on somewhat the following lines:—

Rice, Burma or country	18 ozs.
Different dals available	4 „
Wheat ata daily	4 „
or	
Fish, in place of wheat ata twice a week when procurable	4 „
Vegetables	6 „
Salt	$\frac{1}{2}$ „
Condiments, etc.	as in present scale.

We have placed all the prisoners in Puri jail on diets somewhat similar to these for a period of about six months; a report of the effects of the change, with observations on the degree of nitrogenous metabolism, the health of the prisoners, the effect on body weight, etc., will be found in its proper place. We do not consider that an animal protein is at all essential in the dietaries of a practically purely vegetarian people, and, therefore, would only recommend a change to fish from an economical standpoint; mutton, goat's flesh, etc., are not required.

While we do not consider that an animal protein is necessary there is no doubt that the addition of even a small quantity appears to have a marked influence in assisting the absorption of protein from a diet of the Lower Bengal type. We obtained evidence of this in some work carried out in Midnapore jail.

The custom in that jail is to give what is termed "fish relish"—a very small amount of fish mixed with the rice. It is much in favour with the prisoners and, as fish is cheap in Midnapore, the cost is purely nominal. The following are the results of the protein absorption when a small quantity of fish is added to the ordinary jail diet:—

Twenty prisoners observed over a period of seven days.

Fæces of prisoners pooled in batches of five.

Batch.	Total nitrogen of fæces.	N. of rice.	N. of dals.	N. of vegetables.	N. of fish.	Weight.
	Grms.	Grms.	Grms.	Grms.	Grms.	Lbs.
Twenty prisoners, Bengalis	103·90	150 50	114·80	6·48	7·68	114·8
	97·79	155·78	84·88	6·48	7·68	114·7
	98·39	155·56	110·32	6·48	7·68	114·8
	118·66	151·64	120·52	6·48	7·68	114·9
	84·43	150·49	121·09	6·48	7·68	114·9
	110·41	152·46	104·32	6·48	7·68	114·8
	101·17	157·80	96·37	6·48	7·68	114·8

Total intake—

N. of rice . .	1,074·23 grms.
N. of dals . .	752·30 ,,
N. of vegetables .	45·36 ,,
N. of fish . .	53·76 ,,
Total nitrogen intake .	1,925·65 grms.

Total output—

N. of fæces . . . . 714·75 grms.

Total nitrogenous metabolism = 1,925·65 —714·75 grms. = 1,210·90 ,,
= 62·88 p.c. of the nitrogen the diet
= 8·65 grms. of nitrogen per man daily.

To this should really be added, in order to make the results comparable with those in which the nitrogen of the urine was taken as the criterion, a certain amount of nitrogen to cover the quantity passing out in the intestinal secretions. This amount has been variously estimated; but, accepting v. Noorden's value of

0·2 grms. nitrogen daily, we bring the nitrogenous metabolism up to 8·85 grms. per man daily.

When this result was contrasted with the average 7·55 grms. of nitrogen found for the absorption on the full jail diet, it appeared possible that the addition of a small quantity of fish had exerted a very decided influence in assisting the absorption of protein from the jail dietary. As the quantity of nitrogen per man daily derived from fish was only 0·4 grms., and as it seemed to increase the protein absorption from the diet by more than this amount, it was at first thought probable that the animal protein had caused an increase in protein absorption greater than could be accounted for in the amount of nitrogen furnished by the fish. But, while not denying that an animal protein may by its presence exert a favourable influence on the absorption of vegetable protein, these results are open to a simpler explanation. If the diet consumed by the prisoners be examined we find that instead of the whole 26 ozs. being eaten, only—on an average—23 ozs. were eaten, and that the full 6 ozs. of the different dals were not consumed. So that, besides the addition of fish, we have two factors present, both of which we have proved to have a decided influence in increasing the amount of protein absorption. When these two factors are taken into account and the absorption from fish is added, the margin of difference is too small for us to be able to say positively that the fish exerted any marked influence in increasing the absorption of protein from the other constituents of the diet. For we have shown that with a diet composed of 23 ozs. of rice and 6 ozs. of dal 8·09 grms. of nitrogen are absorbed; also that a diminution in the amount of dal to about 5 ozs.—as happened in these observations—is followed by an increased absorption. When the absorption from 0·4 grms. of nitrogen in the fish is added, and also the slight increase due to the decrease in the amount of dal, the total absorption would come, almost within the limits of experimental error, to the 8·85 grms., which was found to be absorbed by the Midnapore prisoners.

It would not appear, therefore, that the addition of this small amount of fish to the diet had much influence on the absorption of protein from the rice and dal, at least, not when rice and dal were given in quantities of 23 ozs. and 5 ozs., respectively. Nevertheless, we believe that if it were found to be economical the addition of a little fish to the diet would be much to the advantage of the prisoners. It is not, however absolutely necessary, and the cost in some of the jails might be prohibitive.

It could be done easily, we believe, in Puri, Midnapore, Buxar and Bhagalpur jails, where fish is available in large quantities, either by purchase or by using prison labour. In fact fish is available at cheap rates all over Bengal.

This brings us to an end of our investigations on the dietaries of Lower Bengal jails, and the effects of certain modifications of these that have been

suggested. Granting that we are correct in assuming that the prisoner, on the average, lives on 7·55 grms. of nitrogen per day and that he remains healthy and even puts on flesh on this amount, there is no urgent necessity to increase his nitrogenous metabolism. But, when we find that the quantities of the component parts of the diets are so great that they are beyond the amounts from which the best absorption can take place, we have a very strong indication for the reduction of those quantities to something approaching proper limits. Those limits we have tried to lay down, and we believe that we have succeeded in defining them.

We find 18 ozs. of rice per man daily to be the amount from which a maximum absorption takes place; we believe that it will be to the advantage of the prisoners to reduce the dal to 4 ozs. per man daily and substitute for the 2 ozs. dal cut off, 4 ozs. of wheat ata—in certain prisons giving, say twice a week, 4 ozs. of fish in place of the wheat ata. There is no doubt that in addition to being beyond the amount from which a maximum absorption is obtained, the 6 ozs. of dal of the jail diet have a decided tendency to cause diarrhœa and digestive disturbances; we have therefore no hesitation in recommending the reduction of this quantity to 4 ozs.

B.—BEHARI DIET.

We now come to a consideration of diets in which the quantity of rice should not be the outstanding feature. The Beharis are much more a wheat-eating than a rice-eating people, and therefore a larger proportion of the protein of the dietaries of Behar jails is derived from wheat ata than from rice. The effect of this is that the diet is very much superior to that of Lower Bengal jails in the quantities of the proximate principles offered, more particularly with regard to the amount of protein and fat.

The diet scales laid down for Behari jails are:—

Burma or country rice	16 ozs.	per man daily.
Different dals available	6 ,,	
Wheat ata	10 ,,	
or		
Makkai ata	12 ,,	
Vegetables	6 ,,	
Condiments, etc.	as before	

We shall take up the investigations on the nutritive value of these diet scales under the same heads and in the same order as was done with regard to Bengali diets. The experience gained in Bengal jails led us at once to the proper method of investigation so that, instead of wasting time in trying to find a constant co-efficient of absorption for the protein of the different elements of the diets, we accepted the established fact of the previous results that the co-efficient of

protein absorption is not constant, but varies with the quantities of the food materials forming the dietunder investigation. We therefore arranged different series of observations in which, when all but one of the constituents of the diet were constant, the actual material under investigation was made to vary. By this means we were able to discover with what particular amount of rice, dal, or ata the protein absorption was at a maximum, and were able to plot out the curves thus obtained so as to show at a glance the effects of the varying quantities of the different food materials. When we came to a study of the Behari diets we fully expected to find a very much larger percentage absorption of protein than in the Bengali; such, however, was not the case: the protein absorption from the full diet of Behar jails is only very slightly higher than for Bengal jails. The actual amount of nitrogen undergoing metabolism was, however, on a much higher level. Again the reason for this poor percentage of protein absorption was not difficult to find: it was to be attributed to the same factors that were in force in the case of the full Bengal jail diets, *viz.*, the vegetable food materials were in quantities greater than the digestive juices were able to deal with to the best advantage. Again we found that by reducing some of the elements an increased relative and actual absorption took place; it was, therefore, our aim to discover with what particular combinations of quantities of these food-stuffs the best absorption was possible. Having worked out this, we at once obtain that combination which leaves the smallest residue for intestinal putrefaction and fermentation, and from which waste is at a minimum. This would, therefore, also be the combination most economical to the State in the dieting of the criminals of Behar.

SECTION 1.

1. The Value of the Behari Diet in Proximate Principles.

As in the case of Bengal jails we give the average values: certain differences will arise according to the samples of wheat or dal in use. The values given below are based on the analyses of the food-stuffs that were in use in the Behar jails at the time the investigations were carried out:—

TABLE IX.

WHEAT DIET.

PROXIMATE PRINCIPLES.	Rice.	Wheat ata.	Makkai ata.	Dals.	Vegetables.	Mustard oil.	Value of diet in grms.
	Grms.	Grms.	Grms.	Grms.	Grms.	Grms.	
Protein	30·85	34·71	..	37·43	3·68	..	106·67
Carbohydrate . .	338·39	201·35	..	93·58	10·00	..	643·32
Fat . . .	4·30	5·67	..	4·25	1·58	17·35	33·15

Makkai Diet.

Proximate principles.	Rice.	Wheat ata	Makkai ata.	Dals.	Vegetables.	Mustard oil.	Value of diet in grms.
	Grms.	Grms.	Grms.	Grms.	Grms.	Grms.	
Protein	30·85	..	32 50	37·43	3·68	..	104·64
Carbohydrate . .	338·39	..	234 82	93·58	10·00	..	676·79
Fat	4·30	..	17 00	4·25	1·58	17·35	44·48

These figures we may accept as a fair average of the Behari diet from day to day. Comparison with the diet of Lower Bengal will show the higher value in both protein and fat with very little difference in the carbohydrate. We need not again refer to the seemingly very high value of these diets as compared with those in force in convict prisons in England; all we have had to say in discussing the dietaries of Lower Bengal applies with even greater force with regard to the diets of Behar. The difference between these two types of dietaries is due to the substitution of 10 ozs. of wheat ata or 12 ozs. of makkai ata (maize or Indian corn) for 10 ozs. of rice. While the reduction in the quantity of rice means a great lessening in the absolute bulkiness of the diet, our investigations show that the decrease is not sufficient to permit of the best use being made of its protein element. Further, the excessive carbohydrate element is again very conspicuous—all the more so in this diet because of the greater quantity of fat furnished by the wheat and maize.

We may sum up our criticism of these dietaries by saying that, had we been able to obtain evidence of a protein absorption at all close to the percentage obtained with European dietaries, we should not have considered the amount of protein offered in the Lower Bengal or Behari diet scales to be much in excess of what might be considered necessary. In our opinion the great defects are the very low percentage of the protein element that is absorbed, and the large amount left over in the intestinal canal. These are defects common to all vegetable diets, but in none to the same extent as in the dietaries of Bengal jails; in these they are increased to an enormous extent by the large amounts of bulky food-materials consumed, and besides the mere bulk, the intestinal tract has also to contend with pathological processes set up by the presence of excessive carbohydrate material undergoing fermentation.

If, from the 100 grms. of protein offered in these diets we had an absorption of 85 per cent, then, even if the amount of nitrogen undergoing metabolism might be considered greater than absolutely necessary, still the prisoners would be

placed on a high plane of nitrogenous metabolism which, as we have good reason to believe, would tend to increase their general physique and power of resisting infection and, at the same time, leave merely the normal quantity of residual waste: but, instead of this, with a protein absorption of little over 50 per cent. the prisoners are placed on a low level of nitrogenous metabolism, their physique, nutrition and power of resisting infection are lessened and, at the same time, their liability to auto-infection and auto-intoxication is increased by the presence of a splendid culture medium for micro-organismal growth within the body derived from the 50 per cent. residue of the jail diet. Another point not to be lost sight of is the avoidable waste of food materials, with its consequent expense to the State.

Our objection to these dietaries therefore is not that the diet offered is excessive and thus entails a high level of nitrogenous metabolism, but that on account of its peculiar composition and of the large quantities of the food materials entering into that composition, the absorption from it is lower than it should be. Along with Lewis, Macnamara and all others who have made a study of the subject, we would decrease the quantities of the food-stuffs; but, in contradistinction to other observers, we would do so not because the diet gives too high a level of nitrogenous metabolism but in order to raise the level of nitrogenous metabolism and afford the digestive juices an opportunity of carrying on their work in a physiological manner.

We now pass to a review of the investigations carried out in Buxar and Bhagalpur jails on the prisoners of Behar.

SECTION 2.

2. The Amount of Nitrogen undergoing Metabolism on the Ordinary Jail Diet of Behar.

We attempted to obtain the average amount of protein absorption from the full Behari dietaries in Buxar jail and Bhagalpur jail. In Buxar jail Burma rice is used, and here we experienced the same difficulty as encountered in the Presidency Jail, Calcutta, where Burma rice was also in use: it was found absolutely impossible to get the full ration of Burma rice consumed for a sufficient number of days to obtain reliable results. In fact, in all the different observations made we never once got the full 16 ozs. of Burma rice eaten. On the other hand, in Bhagalpur jail, where country rice is in use we had no difficulty in having the full diet eaten—this is analogous to what we found true for Puri jail where also country rice was the variety given.

We shall, therefore, take up the observations on the two kinds of rice separately in Table X.

TABLE X.

(a) Investigations to determine the degree of nitrogenous metabolism on the ordinary scale of diet for Beharis.

Buxar Jail.

(i) With Burma rice—

Burma rice 80 ozs.	batch of five men.
Wheat ata 50 ozs.	
Different dals 30 ozs. . . .	
Vegetables 30 ozs.	

Four batches of five prisoners in each batch observed over five consecutive days.

In no case did the prisoners consume the full amount of Burma rice.

Batch I.	Quantity. of urine.	Total N. of urine.	Weight of prisoners.	N. of Burma rice.	N. of different dals.	N. of ata wheat.	N. of vegetables.
	C. C.	Grms.	Lbs.	Grms.	Grms.	Grms.	Grms.
Five prisoners, Beharis .	11,280	38·29	107·3	21·63	30·05	27·75	2·36
	9,600	39·51	107·5	25·33	30·05	27·75	2·36
	11,500	45·08	108	19·58	33·81	24·25	2·36
	9,500	42·02	107·6	22·88	30·05	27·75	2·36
	8,800	39·30	107·4	19·82	30·05	27·75	2·36

Remarks.

Of the 80 ozs. of Burma rice in the diet during the five days on an average only 64·25 ozs. were eaten.

Batch II.	C. C.	Grms.	Lbs.	Grms.	Grms.	Grms.	Grms.
Five prisoners, Beharis .	6,550	37·18	115·2	23·46	30·05	27·75	2·36
	6,790	46·67	115·4	25·33	30·05	27·75	2·36
	9,830	44·86	115·3	23·22	33·81	27·75	2·36
	8,500	39·62	115·2	26·88	30·05	27·75	2·36
	8,010	40·59	115·3	19·48	3 ·05	27·75	2·36

Remarks.

Of the 80 ozs. of Burma rice in the diet during the five days on an average only 67·28 ozs. were eaten.

Batch III.	Quantity of urine.	Total N. of urine.	Weight of prisoners.	N. of Burma rice.	N. of different dal.	N. of ata wheat.	N. of vegetables.
	C. C.	Grms.	Lbs.	Grms.	Grms.	Grms.	Grms.
Five prisoners, Beharis.	7,320	41·96	116·2	23·35	30·05	27·75	2·36
	7,300	37·09	115·6	24·46	30·05	27·75	2·36
	8,360	45·29	116·4	23·22	33·81	27·75	2·36
	8,020	37·38	116·4	22·88	30·05	27·75	2·36
	7,840	45·16	116·2	23·80	30·05	27·75	2·36

Remarks.

Of the 80 ozs. of Burma rice in the diet during the five days on an average only 68·6 ozs. were eaten.

Batch IV.	C. C.	Grms.	Lbs.	Grms.	Grms.	Grms.	Grms.
Five prisoners, Beharis .	7,660	42·52	122	17·95	30·05	27·75	2·36
	7,780	40·68	121·8	21·62	30·05	27·75	2·36
	8,210	48·06	122·2	23·22	33·81	27·75	2·36
	7,640	42·62	122	19·27	30·05	27·75	2·36
	7,030	45·37	122	18·22	30·05	27·75	2·36

Remarks.

Of the 80 ozs. of Burma rice offered in the diet on an average only 57 ozs. were eaten.

The different dals in use were gram dal, arhar dal and massur dal.

Points brought out in these investigations :—

(1) Batch I—

Total intake of nitrogen—		Total output of nitrogen—	
N. of rice . . .	109·24 grms.	N. of urine . . .	204·20 grms.
N. of dals . . .	154·01 ,,	·5 grm. per day constant	12·50 ,,
N. of wheat ata . .	135·25 ,,	Total N. metabolism	216·70 ,,
N. of vegetables . .	11·80 ,,	= 8·66 grms. of N. per man daily,	
Total N. intake . .	410·30 ,,	= 52·81 per cent. of N. of diet.	

Batch II—

Total intake of nitrogen—		Total output of nitrogen—	
N. of rice . .	118·37 grms.	N. of urine . . .	208·92 grms.
N. of dals . .	154·01 „	·5 grm. per day constant . .	12·50 „
N. of wheat ata .	138·75 „		
N. of vegetables .	11·80 „		
Total N. intake	422·93 „	Total N. metabolism .	221·42 „

= 8·85 grms. of N. per man daily,
= 52·35 per cent. of N. of diet.

Batch III—

Total intake of nitrogen—		Total output of nitrogen—	
N. of rice . .	117·71 grms.	N. of urine .	206·88 grms.
N. of dals . .	154·01 „	·5 grm. per day constant .	12·50 „
N. of wheat ata .	138·75 „		
N. of vegetables .	11·80 „		
Total N. intake .	422·27 „	Total N. metabolism	=219·38 „

= 8·77 grms. of N. per man daily,
= 51·95 per cent. of N. of diet.

Batch IV—

Total intake of nitrogen—		Total output of nitrogen—	
N. of rice . .	100·28 grms.	N. of urine . .	219·25 grms.
N. of dals . .	154·01 „	·5 grm. per day constant . .	12·50 „
N. of wheat ata .	138·75 „		
N of vegetables	11·80 „		
Total N. of intake .	404·84 „	Total N. metabolism	= 231·75 „

= 9·26 grms. of N. per man daily,
= 57·24 per cent. of N. of diet.

(2) The batches I, II and III have an almost identical intake of nitrogen derived from the same sources and, as will be seen from the figures giving the amounts of nitrogenous metabolism per man daily, the total nitrogen output is almost identical also. We may, therefore, accept the average of the amount of nitrogenous metabolism of these three batches as being the average amount of nitrogen made use of from the ord.nary diet of the Behari prisoners. This is as follows :—

Batch I. N. of intake .	410·30 grms.	N. metabolism	216·70 grms.
„ II. N. of „ .	422·93 „	N. „	221·42 „
„ III. N. of „ .	422·27 „	N. „	219·38 „
Total N. „ .	1255·50 „	N. „	657·50 „

=52·36 per cent of N. of diet,
= 8·76 grms. N. per man daily.

Therefore we may conclude that the amount of nitrogenous metabolism from a diet composed of—

Burma rice	13·34 ozs.	for each prisoner per day
Wheat ata	10·00 „	
Dals	6·00 „	
Vegetables	6·00 „	

and equivalent to an intake of 16·75 grms. of nitrogen daily is, under ordinary circumstances, 52·36 per cent. of the nitrogen of the diet or 8·76 grms. of nitrogen per man daily.

(3) Batch IV had to be excluded from this average, for the amount of Burma rice consumed by the batch was much below the average consumption of rice by the other three batches and, as will be evident from these investigations, a decrease in the amount of rice from the ordinary jail quantity always leads to a greater absolute and relative absorption of the nitrogen of the food.

In Batch IV—

Nitrogen of intake is 404·84 grms., of which 100·28 grms. is from rice. The amount of nitrogenous metabolism = 231·75 grms.

= 57·24 per cent. of the nitrogen of the diet,
or 9·26 grms. of nitrogen per man daily.

By contrasting the nitrogenous metabolism (average) of batches I, II and III with batch IV, it is evident that a reduction in the quantity of rice from 13·34 ozs. to 11·40 ozs. per man daily is at once accompanied by an increase in the relative and actual amount of nitrogen absorbed, *i.e.*, from 52·36 per cent. to 57·24 per cent., and from 8·76 grms. to 9·26 grms. of nitrogen per man daily.

On the whole the average nitrogenous metabolism in Buxar jail was on a low level, due probably to many causes. At the time these observations were carried out the health of Buxar jail was bad, owing to an epidemic of dysentery and much diarrhœa. Another factor was probably the poor condition of the dals used in these observations. The change for the better that took place in later experiments when mung dal was given in place of the other dals was very marked.

(4) This investigation on picked healthy men on hard labour further shows that the prisoners are quite unable to consume the full quantity of Burma rice sanctioned for their diet.

Each prisoner is allowed 16 ozs. of rice daily along with the other constituents of the diet scale.

The average consumption of rice of these 20 men observed for seven consecutive days works out as 12·86 ozs. instead of the 16 ozs. provided in their daily diet.

Even this was probably a higher consumption than normal, for we were anxious at this stage to get the prisoners to eat all the food provided, in order to obtain the average amount of protein absorbed from the full diet, so that the men were pressed to eat more than they really felt they needed. Further evidence that 16 ozs. per man daily of Burma rice is too great a quantity is afforded by the amounts found to be consumed by different batches during the two months that the investigations were going on in Buxar jail. Thus—

(*a*) A batch of 5 healthy Behari prisoners observed for seven consecutive days was given a diet composed of—

Burma rice . .	80 ozs.	or 16 ozs. per man daily
Wheat ata . .	50 „	„ 10 „ „ „ „
Mung dal . .	30 „	„ 6 „ „ „ „
Vegetables . .	30 „	„ 6 „ „ „ „

on an average only 62·73 ozs. or 12·54 ozs. per man daily were eaten.

(*b*) Another batch of 5 healthy Behari prisoners observed for seven consecutive days was given a diet composed of—

Burma rice . .	80 ozs.	or 16 ozs. per man daily
Makkai ata . .	50 „	„ 10 „ „ „ „
Mung dal . .	30 „	„ 6 „ „ „ „
Vegetables . .	30 „	„ 6 „ „ „ „

on an average only 60·74 ozs. or 12·15 ozs. per man daily were eaten.

(*c*) Another batch of 5 healthy Behari prisoners observed for seven consecutive days was given a diet composed of—

Burma rice . .	70 ozs.	or 14 ozs. per man daily
Makkai ata . .	50 „	„ 10 „ „ „ „
Mung dal . .	30 „	„ 6 „ „ „ „
Vegetables . .	30 „	„ 6 „ „ „ „

on an average only 56·35 ozs. or 9·47 ozs. per man daily were eaten.

In (*b*) and (*c*) the ordinary quantity of 12 ozs. of makkai ata per man daily had been reduced to 10 ozs., yet the prisoners could not consume more than an average of 12·35 ozs. of Burma rice each per day.

We may therefore conclude that about 12 ozs. of Burma rice is the maximum quantity that a Behari prisoner will consume when he is on the full Behari diet, or even when the amount of makkai ata is decreased from 12 ozs. to 10 ozs. per man daily.

Bhagalpur Jail.

Beharis.

(ii) **Country rice.—Investigations to determine the average amount of nitrogenous metabolism by Behari prisoners on the ordinary scale of diet sanctioned for Beharis.**

Country rice	160 ozs.	One batch of 10 prisoners observed for five consecutive days.
Wheat ata	100 ,,	
Arhar dal	60 ,,	
Vegetables	60 ,,	

The full amount of country rice—16 ozs. per man daily—was consumed.

BATCH A.	Quantity of urine.	Total N. of urine.	Weight of prisoners.	N. of country rice.	N. of wheat ata.	No. of arhar dal.	N. of vegetables.
	C. C.	Grms.	Lbs.	Grms.	Grms.	Grms.	Grms.
Ten prisoners, Beharis	15,310	92·16	125·6	49·95	56·16	59·64	4·72
	15,710	93·91	125·5	49·95	56·16	59·64	4·72
	15,630	88·84	125·9	49·95	56·16	59·64	4·72
	15,980	91·50	125·7	49·95	56·16	59·64	4·72
	17,110	94·13	125·7	49·95	56·26	59·64	4·72

Total intake of nitrogen—

N. of country rice . .	249·75 grms,
N. of wheat ata . .	280·80 ,,
N. of arhar dal . .	298·20 ,,
N. of vegetables . .	23·60 ,,
Total N. of intake . .	852·35 ,,

Output of nitrogen—

N. in urine	460·54 grms.
·5 grm. N. constant . .	25·00 ,,
Total N. metabolism . .	485·54 ,,

= 9·71 grm. N. per man daily,
= 59·96 per cent. of N. of diet is absorbed.

We may therefore conclude that the amount of nitrogenous metabolism from a diet composed of—

Country rice . . .	16 ozs.	for each prisoner per day,
Wheat ata	10 ,,	
Arhar dal	6 ,,	
Vegetables	6 ,,	

and equivalent to an intake of 17·07 grms. nitrogen daily is 56·96 per cent. or 9·71 grms. of nitrogen per day per man.

Contrast this result with the average nitrogenous metabolism of prisoners in Buxar jail on Burma rice, in whose case only 52·36 per cent. of the nitrogen of

diet was absorbed or only 8·76 grms. nitrogen per man daily. This would appear to support the view that prisoners who are given a free choice as regards the quantity of rice they may eat—

(1) are able to consume much larger quantities of country rice than of Burma rice, and

(2) that the protein of country rice is more easily absorbed than that of Burma rice, when given in quantities of from 12 to 16 ozs. per man daily to those who are accustomed to it and not to Burma rice.

We think that there is no doubt that both these conclusions are probably correct. Among Bengalis on their 26 ozs. of dry rice per day the only place where the full diet was eaten was at Puri, and the rice in use was grown locally —this contrasts very markedly with what was found in the Presidency Jail, Calcutta, where we gave up all hope of obtaining a constant consumption, even for one week, of the full diet, the rice in use there being Burma rice.

Besides the actual experimental evidence that the protein of country rice is more easily made use of and assimilated by prisoners in Bengal jails, there would appear to be an interesting explanation, in the light of Pawlow's work on the digestive glands, that such a result is only to be expected. The prisoners do not care for Burma rice nearly so much as for the local product and freely state that it is heating, filling and hard to digest, causing heart-burn and a feeling of heaviness in the stomach. It is a type of rice different from what they have been accustomed to live on, and there is no doubt that mental processes have a decided influence over absorption from a more or less strange form of diet.

This influence of the mind on the secretion of the digestive juices has been admirably worked out by Pawlow, and it very probably explains to some extent the relative absorbabilities of the protein of Burma and country rice.

For the sake of clearness we might contrast the results obtained in Buxar with Burma rice and in Bhagalpur with country rice, and see what other factors should be taken into account.

In Buxar jail, we had—

15 Behari prisoners, observed for one week, on a diet for each man composed of—

Burma rice . .	13·34 ozs.	=	in N.	4·60 grms.
Wheat ata . .	10·00 „	=	„	5·55 „
Different dals . .	6·00 „	=	„	6·16 „
Vegetables . .	6·00 „	=	„	·48 „
			Total N.	16·79 „

Nitrogenous metabolism 8·76 grms. of N. per man daily.

In Bhagalpur jail we had—

10 Behari prisoners, observed for one week, on a diet for each man composed of—

Country rice . . .	16·00 ozs.	=	in N.	4·99 grms.
Wheat ata . . .	10·00 ,,	=	,,	5·61 ,,
Arhar dal . . .	6·00 ,,	=	,,	5·96 ,,
Vegetables . . .	6·00 ,,	=	,,	·48 ,,
			Total N.	17·04 ,,

Nitrogenous metabolism 9·71 grms. N. per man daily.

The total difference in intake of nitrogen per day is 0·29 grm. in favour of the Bhagalpur prisoners, but the difference in the amount of nitrogenous metabolism is no less than 0·95 grm. per day, an amount greater than could be accounted for by the difference of intake. This is very evident if instead of taking 1 man for 1 day we look at the figures of 5 men for 5 days—

Difference in N. of intake = 7·67 grms. in favour of Bhagalpur.
,, ,, metabolism =23·64 ,, ,, ,, ,, ,,

Therefore, with a difference in the nitrogen intake of 7·67 grms. we get a difference in the amount of nitrogenous metabolism of 23·64 grms. This can only be explained by a difference in the relative absorbability of the protein in the two types of diet, and—eliminating the protein of wheat ata and vegetables as they were practically identical—the cause must lie in the protein of Burma rice and mixed dal as compared with that of country rice and arhar dal.

It will be evident from a comparison of all the results obtained at these two jails, that the protein metabolism of prisoners in Buxar jail was always on a lower level than in Bhagalpur. The percentages of protein absorbed from the different diets in Buxar jail were also lower than those obtained in Bhagalpur.

The reason of this lower relative and absolute protein absorption by the prisoners of Buxar jail is difficult to explain. In all probability several factors combined to give the low results—

(*a*) The dals in use (as already pointed out) were of inferior quality, whereas in Bhagalpur jail arhar dal alone was given and this is the form of dal most in favour with the Behari; so that here again mental processes may have been in action.

(*b*) Burma rice, as we have seen, was not at all liked by the prisoners, and they had not been long enough on this class of rice to have got accustomed to it; in the Presidency Jail, Calcutta, Burma rice has been in use for over three years, so that the long term prisoners had grown accustomed to its use.

(*c*) A third and more indefinite factor was the unhealthy condition of Buxar jail at the time when we began our observations. The general health and tone of the jail improved very much later and, as will be seen in the subsequent results, a much better protein absorption was obtained from diets very similar in composition, the only difference being the substitution in them of mung dal for the different dals in use in the first series of observations.

(*b*) The amount of nitrogen undergoing metabolism by prisoners derived from the hill tribes of Darjeeling on diets of the Behari type.

As we shall have to deal with hill men separately there is nothing to be gained by taking up this part of the subject now. Suffice it to say that on the whole they absorbed slightly more than Beharis from the same diet.

The diet given in the Darjeeling jail is not by any means composed of the kinds of food materials that hill men are accustomed to. It is of a very inferior type and this jail served as the only example—with perhaps the exception in the case of certain tribes, of Ranchi jail—of a diet being penal, *i.e.*, of the prisoners losing from a dietetic standpoint by entering jail.

SECTION 3.

3. The effect on nitrogenous metabolism of varying the quantities of the components of the ordinary jails dietaries of Behar jails.

The work in connection with this section is very extensive, and was carried out very thoroughly in both Buxar and Bhagalpur Central jails. As the conditions in these two jails were somewhat different we shall have to take up the investigation separately for each jail.

In Buxar jail Burma rice was given whereas country rice was used in Bhagalpur jail. We shall deal first with Buxar jail and its Burma rice, and afterwards with Bhagalpur jail and country rice. Further, in Buxar jail we kept to mung dal throughout the whole investigation and in Bhagalpur jail used arhar dal only.

The method of enquiry was to arrange a series of diets in which one constituent varied while all others remained constant—the conditions being kept, as far as possible, the same throughout. By this means we were able to obtain a series of results demonstrating the effects of varying quantities of each particular component whilst all the others were constant; and thus to discover the particular quantity of each component from which a maximum absorption took place when it was combined with non-varying quantities of the other constituents of the dietaries.

(a) Buxar Jail.

(i) Investigations to obtain the different degrees of nitrogenous metabolism on diets composed of Burma rice, wheat ata, mung dal and vegetables—all constituents of the diets, except rice, remaining constant.

TABLE XI.

SCHEME OF DIETS.

CONSTANTS.						
Wheat ata . .	50 ozs.	+	Burma rice	70 ozs.	Diet I.
Mung dal . .	30 „		„ „	63 „	Diet II.
Vegetables . .	30 „		„ „	60 „	Diet III.
			„ „	50 „	Diet IV.
			„ „	40 „	Diet V.

Diet I.

Five Behari prisoners observed for five consecutive days on each diet.

BATCH X.	Quantity of urine.	Total N. of urine.	Weight.	N. of Burma rice.	N. of mung dal.	N. of wheat ata.	N. of vegetables.
	C. C.	Grms.	Lbs.	Grms.	Grms.	Grms.	Grms.
Five prisoners, Beharis	12,390	50·99	108	23·80	34·59	27·75	2·36
	8,200	41·08	107·9	23·80	34·59	27·75	2·36
	9,640	48·18	107·8	23·80	34·59	27·75	2·36
	10,000	44·66	107·8	23·80	34·59	27·75	2·36
	8,000	42·44	107·9	23·80	34·59	27·75	2·36

This was the only occasion in which even 70 ozs. of Burma rice were eaten.

Diet II.

BATCH X.	7,850	47·20	106·8	20·59	34·57	27·75	2·36
	7,640	47·11	106·8	18·46	35·59	27·75	2·36
Five prisoners, Beharis	10,610	47·37	106·7	21·18	34·59	27·75	2·36
	8,540	47·82	106·7	22·18	34·59	27·75	2·36
	8,880	46·63	106·8	24·14	34·59	27·75	2·36

80 ozs. of Burma rice were offered in this diet but on an average only 63 ozs. were eat en.

Diet III.

Batch Y.	Quantity of urine.	Total N. of urine.	Weight.	N. of Burma rice.	N. of mung dal.	N. of wheat ata.	N. of vegetables.
	C. C.	Grms.	Lbs.	Grms.	Grms.	Grms.	Grms.
Five prisoners, Beharis	9,070	49·01	120·4	20·40	34·59	27·75	2·36
	8,600	49·48	120·4	20·40	34·59	27·75	2·36
	10,150	48·74	120·4	20·40	34·59	27·75	2·36
	11,120	44·21	120·6	20·40	34·59	27·75	2·36
	8,400	47·21	120·4	20·40	34·59	27·75	2·36

Diet IV.

Batch Z.	9,730	45·63	125·4	17·00	34·59	27·75	2·36
Five prisoners, Beharis	9,160	45·14	125·4	17·00	34·59	27·75	2·36
	9,730	43·88	125·4	17·00	34·59	27·75	2·36
	10,300	45·23	125·5	17·00	34·59	27·75	2·36
	8,800	42·87	125·4	17·00	34·59	27·75	2·36

Diet V.

Batch Y.	8,710	44·32	120·6	13·60	34·59	27·75	2·36
Five prisoners, Beharis	8,000	42·22	120·7	13·60	34·59	27·75	2·36
	8,400	43·86	120·6	13·60	34·59	27·75	2·36
	8,460	46·42	120·6	13·60	34·59	27·75	2·36
	9,210	44·41	125·0	13·60	34·59	27·75	2·36

What do we learn from the series regarding the amount of nitrogen undergoing metabolism ?

Diet I.

Intake—

N. of Burma rice . .	119·00 grms.
N. of mung dal . .	172·95 ,,
N. of wheat ata . .	138·75 ,,
N. of vegetables . .	11·80 ,,
Total N. of intake .	442·50 ,,

Output—

N. of urine	227·35 grms.
·5 grm. N. constant . .	12·50 ,,
Total N. metabolism . .	239·85 ,,

= 53·97 per cent. of N. of diet,
= 9·59 grms. of N. per day per man.

Diet II.

Intake—		Output—	
N. of Burma rice .	106·53 grms.	N. of urine	233·13 grms.
N. of mung dal .	172·95 ,,	·5 grm. N. constant . .	12·50 ,,
N. of wheat Ata .	138·75 ,,		
N. of vegetables .	11·80 ,,	Total N. metabolism . .	245·63 ,,
		= 57·12 per cent. of N. of diet,	
Total N. of intake . .	430·03 ,,	= 9·82 grms. N. per day per man.	

Diet III.

Intake—		Output—	
N. of Burma rice .	102·00 grms.	N. of urine	238·65 grms.
N. of mung dal .	172·95 ,,	·5 grm. N. constant . .	12·50 ,,
N. of wheat ata .	138·75 ,,		
N. of vegetables .	11·80 ,,	Total N. metabolism . .	251·15 ,,
		= 59·02 per cent. of N. of diet,	
Total N. of intake . .	425·50 ,,	= 10·05 grms. N. per day per man.	

Diet IV.

Intake—		Output—	
N. ot Burma rice .	85·00 grms.	N. of urine	222·75 grms.
N. of mung dal .	172·95 ,,	·5 grm. N. constant . .	12·50 ,,
N. of wheat ata .	138·75 ,,		
N. of vegetables .	11·80 ,,	Total N. metabolism . .	235·25 ,,
		= 57·58 per cent. of N. of diet,	
Total N. of intake . .	408·50 ,,	= 9·41 grms. N. per day per man.	

Diet V.

Intake—		Output—	
N. of Burma rice .	68·00 grms.	N. of urine	221·23 grms.
N. of mung dal .	172·95 ,,	·5 grm. N. constant . .	12·50 ,,
N. of wheat ata .	138·75 ,,		
N. of vegetables .	11·80 ,,	Total N. metabolism . .	233·73 ,,
		= 59·67 per cent. of N. of diet,	
Total N. of intake . .	391·50 ,,	= 9·35 grms. of N. per day per man.	

From the results obtained we get the following :—

PER MAN.

Constants of diets.		Varying amounts of rice.	Diet of scheme.	Degree of N. metabolism per man daily.
Wheat ata 10 ozs. Mung dal 6 ,, Vegetables 6 ,,	+	Burma rice 14 ozs.	Diet I	9·57 grms.
		,, ,, 12·6 ,,	Diet II	9·82 ,,
		,, ,, 12 ,,	Diet III	10·05 ,,
		,, ,, 10 ,,	Diet IV	9·41 ,,
		,, ,, 8 ,,	Diet V	9·35 ,,

The interpretation of these results is easy; their meaning is that with a diet of the Behari type, consisting of 10 ozs. wheat ata, 6 ozs. mung dal and 6 ozs. vegetables, by gradually increasing the amount of the varying constituent—rice—from 8 ozs. upwards, we arrive at a certain quantity from which the protein absorption from the diet containing it is at a maximum. This amount is the optimum for that particular combination of the quantities of the several food

materials entering into the diet, and with the constants made use of in this series we find that the optimum amount of Burma rice is 12 ozs. per man daily. We saw in section (2) that 12 ozs. daily was about the maximum amount of Burma rice that a prisoner was able to consume; so that, when given a free choice, the prisoner eats that quantity of Burma rice from which he is able to derive the maximum advantage.

By plotting out these figures we obtain a graphic record of the varying degrees of nitrogenous metabolism on diets containing different quantities of Burma rice when the other components are constant. This is shown on Chart III.

(ii) Investigations to determine the different degrees of nitrogenous metabolism on diets composed of Burma rice, wheat ata, mung dal and vegetables. All constituents, except the wheat ata of the diets, remaining constant.

TABLE XII.

SCHEME OF DIETS.

CONSTANTS.

Constants					
Burma rice .	. 60 ozs.	+	Wheat ata	60 ozs.	Diet I.
Mung dal .	. 30 „		„ „	50 „	Diet II.
Vegetables .	. 30 „		„ „	40 „	Diet III.
			„ „	30 „	Diet IV.

Diet I.

Five Behari prisoners observed for five consecutive days.

BATCH R.	Quantity of urine.	Total N. of urine.	Weight.	N. of Burma rice.	N. of wheat ata.	N. of mung dal.	N. of vegetables.
	C. C.	Grms.	Lbs.	Grms.	Grms.	Grms.	Grms.
Five prisoners, Beharis	7,600	46·48	119·8	20·40	33·30	34·59	2·36
	9,230	47·16	119·7	20·40	33·30	34·59	2·36
	10,230	49·98	119·8	20·40	33·30	34·59	2·36
	10,800	46·45	119·8	20·40	33·30	34·59	2·36
	8,000	43·23	119·8	20·40	33·30	34·59	2·36
					Different men—same Diet I.		
BATCH X.							
Five prisoners, Beharis	10,050	43·28	108·6	20·40	33·30	34·59	2·36
	10,220	46·35	108·4	20·40	33·30	34·59	2·36
	9,800	43·53	108·6	20·40	33·30	34·59	2·36
	9,920	48·69	108·4	20·40	33·30	34·59	2·36
	8,540	45·44	108·6	20·40	33·30	34·59	2·36

Diet II.

Batch R.	Quantity of urine.	Total N. of urine.	Weight.	N. of Burma rice.	N. of wheat ata.	N. of mung dal.	N. of vege-tables.
	C. C.	Grms.	Lbs.	Grms.	Grms.	Grms.	Grms.
Five prisoners, Beharis	9,070	49·01	120·4	20·40	27·75	34·59	2·36
	8,600	49·48	..	20·40	27·75	34·59	2·36
	10,150	48·74	..	20·40	27·75	34·59	2·36
	11,120	44·21	..	20·40	27·75	34·59	2·36
	8,400	47·21	120·4	20·40	27·75	34·59	2·36

Diet III.

Batch Y.							
Five prisoners, Beharis.	7,030	45·86	125·5	20·40	22·20	34·59	2·36
	7,350	49·38	125·3	20·40	22·20	34·59	2·36
	8,610	53·02	125·2	20·40	22·20	34·59	2·36
	9,670	48·72	125·4	20·40	22·20	34·59	2·36
	8,210	42·64	125·5	20·40	22·20	34·59	2·36

Diet IV.

Batch Z.							
Five prisoners, Beharis.	8,500	42·69	119·8	20·40	16·65	34·59	2·36
	7,800	43·57	..	20·40	16·65	34·59	2·36
	8,360	43·59	120	20·40	16·65	34·59	2·36
	8,900	43·98	..	20·40	16·65	34·59	2·36
	9,560	45·67	119·8	20·40	16·65	34·59	2·36
				Different men—same diet = Diet IV.			
Batch X. Five prisoners, Beharis.	11,160	43·82	107·5	20·40	16·65	34·59	2·36
	10,200	44·41	..	20·40	16·65	34·59	2·36
	11,500	45·07	..	20·40	16·65	34·59	2·36
	10,300	42·97	107·6	20·40	16·65	34·59	2·36
	10,440	42·82	107·5	20·40	16·65	34·59	2·36

What do we learn from this series of investigations regarding the different degrees of nitrogenous metabolism ?

Diet I.

Total intake of N. for the ten days of the two batches R and X . . . . . . 906·50 grms.

Total output of N. in urine for the ten days of the two batches R and X . . { 460·59 grms. / 25·00 „

Total N. metabolism . 485·59 grms.
=53·56 per cent. of N. of diet,
=9·71 grms. N. per man daily.

Diet II.

Total intake of N. . . . . 425·50 grms.

Total output (*see* Table XI, Diet III).
Total N. metabolism . 251·15 grms.
=59·02 per cent. of N. of diet,
=10·05 grms. N. per man daily.

Diet III.

Total intake of N. . . . . 397·75 grms.

Total output—
N. of urine . . 239·63 grms.
·5 grm. N. constant . 12·50 „

Total N. of metabolism . 252·13 grms.
=63·38 per cent. of N. of diet,
=10·08 grms. N. per man daily.

Diet IV.

Total intake of N. for the ten days of the two batches R and X . . . . . . 740·00 grms.

Total output of N. in urine for the ten days of the two batches R and { 438·59 grms. / 25·00 „

Total N. metabolism . 463·59 grms.
=62·64 per cent. of N. of diet,
=9·27 grms. N. per man daily.

From these investigations we get the following results :—

PER MAN.

Constants of Diets.			Varying amounts of wheat ata.		Diet of scheme.	Amount of N. metabolism per man daily.
Burma rice	12 ozs.	+	Wheat ata	12 ozs.	Diet I.	9·71 grms.
Mung dal	6 „		„ „	10 „	Diet II.	10·05 „
Vegetables	6 „		„ „	8 „	Diet III.	10·08 „
			„ „	6 „	Diet IV.	9·27 „

The maximum protein absorption would therefore appear to occur with a diet containing something between 10 and 8 ozs. of wheat ata per man daily—the other constituents remaining constant as in scheme. We may accept it that the optimum amount of wheat ata is 9 ozs. as from the very nearly identical results obtained with 10 ozs. and 8 ozs. respectively the intermediate figure would be the optimum. This corresponds fairly well with what was found in a similar set of experiments on prisoners in Bhagalpur jail, when country rice and arhar dal were given instead of Burma rice and mung dal—the optimum amount there being about 10 ozs. of wheat ata per man daily.

By plotting out these figures we obtain a curve representing the degrees of protein metabolism for different amounts of wheat ata in the diets when the other constituents remain constant—see Chart IV.

By plotting on the same chart the curves obtained for the protein absorption of prisoners in the Bhagalpur jail and in Buxar jail we again find that the Buxar curve is on a lower level than that of Bhagalpur, see Charts IX and XIII. As already mentioned this may be due to the higher degree of absorbability of the protein of country rice or the protein of arhar dal or both; whatever may have been the cause it was very evident, while work was going on in these two Behar jails, that the health of the prisoners in Bhagalpur jail was much better than in Buxar jail.

We met with no difficulty at all in Bhagalpur, and no repetition of any of the diets was found necessary: but, in Buxar several repetitions were required on account of some one of the batch that was the subject of experiment going sick, getting fever, diarrhœa and even dysentery; and, what was even more annoying, undergoing large variations in weight. On account of these and other factors we had to reject many sets of observations in Buxar, due almost entirely to the defective health conditions of the jail; while in Bhagalpur, where the prisoners were a very healthy lot, we had no trouble and did not have to reject a single observation.

(*a*) Buxar Jail.

TABLE XIII.

(iii) Investigations to make certain that the degree of nitrogenous metabolism from a diet containing 60 ozs. of wheat ata, 60 ozs. of Burma rice, 30 ozs. of dal and 30 ozs. of vegetables, shown in Table XII, Diet I, was correct and that changing the kind of dal did not make much difference.

Batches of five Behari prisoners were put on the above diets—the dals made use of being mattar, gram and arhar dals furnishing almost identical quantities of nitrogen.

Five Behari prisoners observed for five consecutive days.

BATCH O.	Quantity of urine.	Total N. urine.	Weight.	N. of Burma rice.	N. of mattar dal.	N. of wheat ata.	N. of vege-tables.
	C. C.	Grms.	Lbs.	Grms.	Grms.	Grms.	Grms.
Five prisoners, Beharis	6,710	46·21	115·8	20·40	30·72	33·30	2·36
	6,830	42·73	115·8	20·40	30·72	33·30	2·36
	6,300	44·71	116·0	20·40	30·72	33·30	2·36
	5,850	47·82	115·9	20·40	30·72	33·30	2·36
	5,870	50·28	115·8	20·40	30·72	33·30	2·36
BATCH P.					N. of *Gram dal.*		
Five prisoners, Beharis	8,240	45·73	116·3	20·40	30·05	33·30	2·36
	8,500	44·44	116·4	20·40	30·05	33·30	2·36
	10,040	45·54	116·2	20·40	30·05	33·30	2·36
	7,300	48·87	116·2	20·40	30·05	33·30	2·36
	8,800	46·24	116·3	20·40	30·05	33·30	2·36
BATCH O.					N. of *Arhar dal.*		
Five prisoners, Beharis	7,500	46·84	115·6	20·40	30·05	33·30	2·36
	6,250	42·30	115·6	18·72	30·05	33·30	2·36
	6,960	42·09	115·8	19·13	30·05	33·30	2·36
	7,950	45·83	115·6	18·79	30·05	33·30	2·36
	7,650	51·11	115·6	18·60	30·05	33·30	2·36

By working these figures out we get :—

BATCH O ON MATTAR DAL.

Total N. intake . . . 433·90 grms. Total N. metabolism . 244·25 grms.
=56·29 per cent. of N. of diet,
= 9·77 grms. of N. per man daily.

BATCH P. ON GRAM DAL.

Total N. intake . . . 430·55 grms. Total N. metabolism . 243·32 grms.
=56·51 per cent. of N. of diet,
= 9·73 grms. N. per day per man.

BATCH O ON ARHAR DAL.

Total N. of intake . . 424·25 grms. Total N. metabolism . 240·67 grms.
=56·50 per cent. of N. of diet,
= 9·62 grms. N. per day per man.

We therefore have very closely similar results for the amount of nitrogenous metabolism in the four diets given, *viz.* :—

Burma rice 12 ozs.	+	Mung dal	6·65 grms.	N.	=9·71 grms.	N.	per day.
Wheat ata 12 ,,		Mattar ,,	6·14 ,,	,,	=9·77 ,,	N.	,, ,,
Vegetables 6 ,,		Gram ,,	6·01 ,,	,,	=9·73 ,,	N.	,, ,,
		Arhar ,,	6·01 ,,	,,	=9·62 ,,	N.	,, ,,

The last diet which contained arhar dal gives a slightly lower figure but the whole of the rice was not eaten which may account for the different result.

These results show conclusively that with 12 ozs. of wheat ata, the amount of nitrogen absorbed is about 9·7 grms. per man daily, which quantity we have shown to be lower than that absorbed when only 10 ozs. of wheat ata are given daily, the other constituents of the dietaries being similar.

Further, they make it probable that an increase in the amount of protein offered in the form of dal is not accompanied by a corresponding increase in the amount of protein undergoing metabolism, *i.e.*, when the amount of protein in the diet is already high.

Thus from the investigations in this series we have :—

		Absorbed per man daily.
Batch R and X, Diet I, Total N. of intake	=906·50 grms.	9·71 grms. N.
N. of Mung dal	=345·90 ,,	
Batch O, Diet I, Total N. of intake	=433·90 ,,	9·77 ,, ,,
N. of mattar dal	=153·60 ,,	
Batch P, Diet I, Total N. of intake	=430·55 ,,	9·73 ,, ,,
N. of gram dal	=150·25 ,,	
Batch O, Diet I, Total N. of intake	=424·25 ,,	9·63 ,, ,,
N. of arhar dal	=150·25 ,,	

this means that we get a practically uniform level of nitrogenous metabolism with diets that vary in the amount of their nitrogen intake per man per day from—

18·13 grms. to 17·36 grms. to 17·22 grms. to 16·97 grms.

This bears out what we have already deduced from the results obtained in all the different investigations, *viz.*, that, in diets of the type given in Bengal or Behar jails, it is useless to increase the amount of protein of the diet by an increase in the quantity of the cereals of which the diet is composed. Instead of an increase beyond the optimum quantity producing a higher level of protein metabolism it has an exactly opposite effect.

Summary of the results of these investigations.

In section (I) we give the average value of the Behari jail diet in proximate principles.

In section (II) the average level of nitrogen metabolism for prisoners on the full Behari diet in Bhagalpur jail and on less than the full diet in Buxar jail will be found.

Under this section we pointed out that it was impossible to get the full ration of Burma rice consumed; and that, when left to themselves, prisoners will eat about 12 ozs. of Burma rice per day in combination with 10 ozs. of wheat ata, 6 ozs. of dal and 6 ozs. of vegetables.

In section (III) we showed that this combination was an optimum, *i.e.*, that from which a maximum protein absorption takes place.

Having found that 12 ozs. per day was the optimum amount of Burma rice, we made use of this as a constant, and worked out the effects of varying the amount of wheat ata in the diets. From the results obtained it would appear that a quantity of (about) 9 ozs. of wheat ata is the optimum amount, when given in combination with 12 ozs. of Burma rice, 6 ozs. of dal and 6 ozs. of vegetables.

We also showed that very similar results as regards nitrogenous metabolism were obtained when mung, arhar, mottar or gram dals were given in equal quantities, and that the greater percentage of nitrogen present in mung dal did not increase the amount of protein absorption.

We now pass to the observations made on similar lines when makkai ata was substituted for wheat ata in the Behari diets. Makkai ata is given in the cold weather only; as it does not keep well, it is impossible to use it the whole year round. Reference to Table IX will show that the value of this diet in proximate principles, while practically the same as that of the wheat diet in protein, is superior in both carbohydrate and fat. It presents, therefore, all the defects of an entirely vegetable diet, with the further disadvantage that the makkai ata can not be baked into bread, and for this reason has to be given in thick hard masses of little or no cohesion. The absorption of protein from diets containing makkai is on the whole on a lower level than when wheat ata is made use of, but the percentage absorption does not differ very markedly.

(iv) Investigation to determine the different degrees of nitrogenous metabolism on diets composed of Burma rice, makkai ata, mung dal and vegetables—all constituents of the diets, except the Burma rice, remaining constant in quantity.

TABLE XIV.

SCHEME OF DIETS.

Constants.					
Makkai ata . .	50 ozs.	} + {	Burma rice . .	70 ozs.	= Diet I.
Mung dal . .	30 ,,		,, ,, . .	60 ,,	= Diet II.
Vegetables . .	30 ,,		,, ,, . .	56 ,,	= Diet III.
			,, ,, . .	50 ,,	= Diet IV.
			,, ,, . .	40 ,,	= Diet V.

Diet I.

Five Behari prisoners observed over five consecutive days.

Batch S.	Quantity of urine.	Total N. of urine.	Weight.	N. of Burma rice.	N. of makkai ata.	N. of mung dal.	N. of vege-tables.
	C. C.	Grms.	Lbs.	Grms.	Grms.	Grms.	Grms.
Five prisoners, Beharis	9,510	40·87	117·3	23·80	22·05	34·59	2·36
	10,340	39·22	117·4	23·80	22·05	34·59	2·36
	9,340	36·93	117·4	23·80	22·05	34·59	2·36
	9,150	32·92	117·3	23·80	22·05	34·59	2·36
	7,510	36·53	117·3	23·80	22·05	34·59	2·36

Diet II.

Batch P.							
Five prisoners, Beharis	9,740	39·68	117·2	20·40	22·05	34·59	2·36
	12,300	40·03	117·4	20·40	22·05	34·59	2·36
	9,280	38·52	117·4	20·40	22·05	34·59	2·36
	9,810	42·30	117·3	20·40	22·05	34·59	2·36
	9,580	39·16	117·2	20·40	22·05	34·59	2·36

Diet III.

Batch O.							
Five prisoners, Beharis	7,700	39·56	115·4	19·19	22·05	34·59	2·36
	6,120	40·86	115·2	19·19	22·05	34·59	2·36
	6,450	37·19	115·4	19·19	22·05	34·59	2·36
	6,650	32·29	115·4	19·19	22·05	34·59	2·36
	9,100	38·29	115·4	19·19	22·05	34·59	2·36

70 ozs. of Burma rice were offered in this diet, but on an average only 56 ozs. were eaten.

Diet IV.

BATCH P.	Quantity of urine.	Total N. of urine.	Weight.	N. of Burma rice.	N. of makkai ata.	N. of mung dal.	N. of vege-tables.
	C. C.	Grms.	Lbs.	Grms.	Grms.	Grms.	Grms.
Five prisoners, Beharis	10,420	39·31	117·4	17·00	22·05	34·59	2·36
	8,150	37·89	..	17·00	22·05	34·59	2·36
	9,240	37·24	117·4	17·00	22·05	34·59	2·36
	10,310	37·52	..	17·00	22·05	34·59	2·36
	8,660	35·02	117·4	17·00	22·05	34·59	2·36

Diet V.

BATCH Q.							
Five prisoners, Beharis	8,540	38·25	124·4	13·60	22·05	34·59	2·36
	8,880	34·18	124·6	13·60	22·05	34·59	2·36
	9,130	36·93	124·4	13·60	22·05	34·59	2·36
	10,370	35·64	124·4	13·60	22·05	34·59	2·36
	8,720	35·64	124·4	13·60	22·05	34·59	2·36

What do we learn regarding the protein metabolism with these different diets?

Diet I.

Total intake of N. . =414·00 grms.

Total output—
N. of urine . . . . 166·47 grms.
·5 grm. N. constant . . 12·50 „

Total N. metabolism . . . 198·97 „
=48·06 per cent. of N. of diet,
= 7·96 grms. per man daily.

Diet II.

Total intake of N. . =397·00 grms.

Total output—
N. of urine . . . . 199·69 grms.
·5 grms. N. constant per day . 12·50 „

Total N. metabolism . . . 212·19 „
=53·45 per cent. of N. of diet,
= 8·48 grms. per man daily.

Diet III.

Total N. of intake. =390·95 grms.	Total output—	
	N. of urine	194·19 grms.
	·5 grm. daily constant . .	12·50 ,,
	Total N. metabolism . . .	206·69 ,,
	=52·58 per cent. of N. of diet,	
	= 8·26 grms. N. per man daily.	

Diet IV.

Total N. of intake . . =380·00 grms.	Total output—	
	N. of urine	186·98 grms.
	·5 grm. N. daily constant .	12·50 ,,
	Total N. metabolism . . .	199·48 ,,
	=52·46 per cent. of N. of diet,	
	= 7·97 grms. N. per man daily.	

Diet V.

Total N. of intake . . =363·00 grms.	Total output—	
	N. of urine	180·27 grms.
	·5 N. grm. per day constant .	12·50 ,,
	Total N. metabolism . . .	192·77 ,,
	=53·10 per cent. of N. of diet,	
	= 7·71 grms. N. per man daily.	

From these investigations we get the following results per man:—

Constants.	Varying amounts of Burma rice.	Diet of scheme.	Amount of nitrogenous metabolism.
Makkai ata . 10 ozs. +	Burma rice 14 ozs.	Diet I	7·96 grms.
Mung dal . 6 ,, +	,, ,, 12 ,,	Diet II	8·48 ,,
Vegetables . 6 ,, +	,, ,, 11·2 ,,	Diet III	8·26 ,,
	,, ,, 10 ,,	Diet IV	7·97 ,,
	,, ,, 8 ,,	Diet V	7·71 ,,

Thus we have again found that an average of 12 ozs. per man of Burma rice is the amount from which the maximum absorption is obtained. This is the more remarkable in this series of experiments, for it will be observed that only 10 ozs. of makkai ata were given per man daily instead of 12 ozs. as laid down in the jail code.

The reason for the diminution was that it seemed hopeless to expect the prisoners to consume the full amount of makkai ata of the jail diet; when tried with 12 ozs. per man daily, even when the quantity of rice was much reduced they could not eat the whole amount for seven days consecutively.

It was, therefore, thought advisable to diminish the makkai ata to 10 ozs. per man daily, so that it could be kept constant in amount while the Burma rice was given in varying quantities.

This again contrasts very markedly with the results obtained at Bhagalpur where country rice was in use. There we had very little difficulty in getting the whole 16 ozs. of rice eaten, but we did experience a certain amount of trouble with the prisoners on makkai ata and rice, as the full diet of these substances is very bulky and was consumed with difficulty.

As will be seen from the run of the figures of the nitrogenous metabolism obtained at Bhagalpur and Buxar, we again get a lower level of protein metabolism in Buxar, similar to that brought out by the curves of protein metabolism when the wheat ata diets were in use. The curves of the protein metabolism with wheat ata, dals and vegetables constant and the rice—country rice in Bhagalpur, Burma rice in Buxar—varying, show on an average 0·4 grm. nitrogen in favour of the Bhagalpur prisoners—see Chart IX ; but the curves obtained now in the case of the makkai diets are not so regular and show a greater difference in favour of the Bhagalpur prisoners—over 1 grm. nitrogen per man daily ; this can only be explained by the fact that the Bhagalpur prisoners were consuming the full 12 ozs. of makkai ata while the Buxar prisoners were on 10 ozs. per day. See Chart XI*a*.

Although there are variations and irregularities in these curves when contrasted with those obtained from prisoners on the wheat diets, yet they show distinctly that the maximum protein absorption is obtained from a diet in which the amount of rice, whether Burma or country, is close to 12 ozs. per man per day. Further, the investigations show that there is nothing to be gained, so far as the nitrogenous metabolism of the prisoners is concerned, by increasing the amount of rice in their diet beyond 12 ozs., for the only effect that a greater quantity of rice can possibly have is so completely to distend the muscular wall of the stomach that its motility is lessened ; and, at the same time, the mere mass of materials increases the difficulty with which the digestive juices meet in penetrating the food-stuffs and in bringing about the changes necessary for absorption to take place.

The results of this investigation we plot out in Chart. V.

(v) Investigations on the degrees of nitrogenous metabolism on diets composed of Burma rice, makkai ata, mung dal and vegetables—all constituents of the diets, except the makkai ata, remaining constant in quantity.

TABLE XV.

SCHEME OF DIETS.

CONSTANTS.

Burma rice .	. 60 ozs.	+	Makkai ata . .	50 ozs.	Diet I.
Mung dal .	. 30 „		„ „ . .	48 „	Diet II.
Vegetables	. 30 „		„ „ . .	40 „	Diet III.

Diet I.

Five Behari prisoners observed for five consecutive days.

Batch B.	Quantity of urine.	Total N. of urine.	Weight.	N. of Burma rice.	N. of mung dal.	N. of makkai ata.	N. of vegetables.
	C. C.	Grms.	Lbs.	Grms.	Grms.	Grms.	Grms.
Five prisoners, Beharis	9,740	39·68	117·2	20·40	34·59	22·05	2·36
	12,300	40·03	117·4	20·40	34·59	22·05	2·36
	9,280	38·52	117·4	20·40	34·59	22·05	2·36
	9,810	42·30	117·3	20·40	34·59	22·05	2·36
	9,580	39·16	117·2	20·40	34·59	22·05	2·36

Diet II.

Batch O.							
Five prisoners, Beharis	7,690	37·89	115·6	20·40	34·59	21·17	2·36
	8,590	40·82	115·8	20·40	34·59	21·17	2·36
	6,900	41·36	..	20·40	34·59	21·17	2·36
	6,400	38·43	..	20·40	34·59	21·17	2·36
	7,030	38·58	115·6	20·40	34·59	21·17	2·36

This batch was offered 60 ozs. of makkai ata per day, but on an average only 48 ozs. were eaten.

Diet III.

Batch S.							
Five prisoners, Beharis	9,560	35·75	117·2	20·40	34·59	17·64	2·36
	7,620	34·78	117·2	20·40	34·59	17·64	2·36
	9,820	41·45	..	20·40	34·59	17·64	2·36
	9,400	35·79	..	20·40	34·59	17·64	2·36
	12,440	43·71	117·2	20·40	34·59	17·64	2·36

What do we learn from these investigations?

Diet I.

Total intake of N. . . =397·00 grms. Total output—

N. of urine	199·69 grms.
·5 grm. N. constant . .	12·50 „
Total N. metabolism . .	212·19 „

=53·48 per cent. of N. of diet,
=8·48 grms. N. per man daily.

Diet II.

Total intake of N. . . =392·60 grms. Total output—

N. of urine	197·08 grms.
·5 grm. N. constant. . .	12·50 „
Total N. metabolism. . .	209·58 „

=53·63 per cent. of N. of diet,
=8·38 grms. N. per man daily.

Diet III.

Total intake of N. . . =374·95 grms. Total output—

N. of urine	191·48 grms.
·5 grm. N. constant . .	12·50 „
Total N. metabolism . . .	203·98 „

=54·40 per cent. of N. of diet,
=8·15 grms. of N. per man daily.

From these investigations we get the following results per man:—

Constants of diets.			Varying amounts of makkai ata.		Diet of scheme.	Amount of N. absorbed per man daily.
Burma rice .	10 ozs.	+	Makkai ata	10 ozs. .	Diet I	8·48 grms.
Mung dal . .	6 „		„ „	9·6 „ .	Diet II	8·38 „
Vegetables .	6 „		„ „	8 „ .	Diet III	8·15 „

It was found useless to try to get more than 10 ozs. per day of makkai ata consumed by the prisoners in Buxar jail, so that our maximum quantity of makkai ata in this series of diets is 10 ozs. per man daily. So far as the observations go, it will be seen, on comparing them with the similar series carried out in Bhagalpur jail with country rice, that they bear out what we found there, *viz.*, that a diet containing up to 10 ozs. per man daily may be taken with advantage, and that by increasing the makkai from 8 ozs. to 9·6 ozs. and then to 10 ozs. for each man daily, we obtain a corresponding gradual increase in the actual amount of nitrogen undergoing metabolism.

We may, therefore, conclude from the results of the experiments in Buxar and, as we shall see, also from those in Bhagalpur Central Jail, carried out with a view to determine the amount of makkai from which the maximum absorption of protein takes place (the other constituents of the diets being constant), that the

quantity laid down in the jail code, *i.e.*, 12 ozs. per man daily is about the maximum quantity that the average prisoner is capable of consuming ; and that, while an increase in this amount does seem to be accompanied by a slight increase in the amount of protein absorbed, the fact that the prisoners cannot consume more than 12 ozs. per day puts any idea of increasing the quantity of makkai ata out of court.

We may now add to our summary the results of these observations, *viz.*, when makkai ata is substituted for wheat ata in the Behari type of diet.

The general effect of the substitution of 10 ozs. of makkai ata for the same amount of wheat ata is to place the plane of nitrogenous metabolism of the prisoners on a distinctly lower level. On the average for varying quantities of Burma rice the lowering of the level of nitrogenous metabolism works out at 1·66 grms. of nitrogen per man daily. This is very clearly brought out by comparing the curves of the two series of investigations—shown on Charts VI and VII.

Another important fact, which is evident from these results and shown on the chart, is that the maximum protein absorption takes place from diets—of either the wheat ata or makkai ata type—in which the 16 ozs. of Burma rice of the jail diet scale have been reduced to 12 ozs. per man daily.

The optimum quantity of makkai ata for a diet composed of 12 ozs. Burma rice, 6 ozs. dal and 6 ozs. vegetables would appear to be over 10 ozs. and, as we shall see from the investigations in Bhagalpur jail, probably lies about 12 ozs. per man daily ; however, this amount is the maximum that the prisoners are capable of eating, and that only when the rice is reduced to 12 ozs.

We may conclude, therefore, that so far as the observations go—

(1) Burma rice may be reduced to 12 ozs. per man daily in either the wheat or makkai ata diet.

(2) The 10 ozs. of wheat ata is the correct amount.

(3) 6 ozs. of different dals is probably beyond the amount from which the maximum absorption can take place, unless the amount of rice is reduced considerably.

(*b*) Bhagalpur Jail.

(i) Investigations to obtain the different degrees of nitrogenous metabolism on diets composed of country rice, wheat ata, arhar dal and vegetables—all constituents, except rice of the diets, remaining constant

TABLE XVI.

SCHEME OF DIETS.

Constants.					
Wheat ata . .	50 ozs.	+	Country rice . .	80 ozs.	=Diet I.
Arhar dal . .	30 „		„ „ . .	70 „	=Diet II.
Vegetables . .	30 „		„ „ . .	60 „	=Diet III.
			„ „ . .	50 „	=Diet IV.
			„ „ . .	40 „	=Diet V.

Diet I.

Behari prisoners observed over five consecutive days on each diet.

Batch A.	Quantity of urine.	Total N. of urine.	Weight.	N. of country rice.	N. of wheat ata.	N. of arhar dal.	N. of vegetables.
	c.c.	grms.	lbs.	grms.	grms.	grms.	grms.
Ten prisoners, Beharis.	15,310	92·16	125·6	49·95	56·16	59·64	4·72
	15,710	93·91	125·5	49·95	56·16	59·64	4·72
	15,630	88·84	125·9	49·95	56·16	59·64	4·72
	15,980	91·50	125·7	49·95	56·16	59·64	4·72
	17,110	94·13	125·7	49·95	56·16	59·64	4·72
Diet II.							
Batch I. Five prisoners, Beharis.	7,100	46·41	127	21·85	28·08	29·82	2·36
	7,900	46·56	127	21·85	28·08	29·82	2·36
	6,860	46·48	127·2	21·85	28·08	29·82	2·36
	9,320	49·97	127·2	21·85	28·08	29·82	2·36
	9,380	50·68	127	21·85	28·08	29·82	2·36
Diet III.							
Batch II. Five prisoners, Beharis.	7,860	52·15	124·1	18·73	28·08	29·82	2·36
	8,270	52·79	124·2	18·73	28·08	29·82	2·36
	6,640	46·20	124·4	18·73	28·08	29·82	2·36
	7,100	48·50	124·2	18·73	28·08	29·82	2·36
	8,150	49·74	124·1	18·73	28·08	29·82	2·36
			Continued on same diet another week. Diet III.				
Batch II. Five prisoners, Beharis.	6,030	50·39	124·2	18·73	28·08	29·82	2·36
	7,060	49·91	124·3	18·73	28·08	29·82	2·36
	6,000	50·98	124·4	18·73	28·08	29·82	2·36
	6,500	48·73	124·3	18·73	28·08	29·82	2·36
	6,960	50·57	124·2	18·73	28·08	29·82	2·36

Diet IV.

Batch I.	Quantity of urine.	Total N. of urine.	Weight.	N. of country rice.	N. of wheat ata.	N. of arhar dal.	N. of vege- ables.
	c.c.	grms.	lbs.	grms.	grms.	grms.	grms.
	8,880	47·73	126·9	15·66 15·66	28·08	29·82	2·36
	5,800	46·81	127·1	15·66 15·66	28·08	29·82	2·36
Five prisoners, Beharis.	7.830	47·24	127·2	15·66 15·66	28·08	29·82	2·36
	8,090	46·54	127·2	15·66 15·66	28·08	29·82	2·36
	8,340	45·76	127	15·66	28·08	29·82	2·36

Diet V.

Batch I.	6,070	36·30	130·2	12·48	28·08	29·82	2·36
	6,550	38·15	130·3	12·48	28·08	29·82	2·36
Four prisoners, Beharis.	5,820	36·91	130	12·48	28·08	29·82	2·36
	6,490	37·97	130·1	12·48	28·82	29·82	2·36
	6,300	36·30	130·2	12·48	28·08	29·82	2·36

What do we learn regarding the degrees of nitrogenous metabolism from these investigations?

Diet I.

Total intake—
- N. of Country rice . 249·75 grms.
- N. of Wheat ata . . 280·80 „
- N. of Arhar dal . . 298·20 „
- N. of Vegetables . . 23·60 „

Total N. of intake . .= 852·35 „

Output—
- N. of urine . . . . . 460·54 grms.
- 5 grms. per day constant . 25·00 „

Total N. metabolism . . . =485·54 „
= 9·71 grms. N. per man daily,
= 56·96 % of N. of diet.

Diet II.

Total intake—
- N. of Country rice . 109·25 grms.
- N. of Wheat ata . . 140·40 „
- N. of Arhar dal . . 149·10 „
- N. of Vegetables . . 11·80 „

Total N. of intake . .=410·55 „

Output—
- N. of urine . . . . . 240·10 grms.
- ·5 grm. daily constant . . 12·50 „

Total N. metabolism . . . =252·60 „
=10·10 grms. N. per man daily,
=61·52 % of N. of diet.

Diet III.

First week.

Total intake—		Total output—	
N. of Country rice .	93·65 grms.	N. of urine	249·38 grms.
N. of Wheat ata . .	140·40 „	·5 grm. per day constant . .	12·50 „
N. of Arhar dal . .	149·10 „		
N. of Vegetables . .	11·80 „	Total N. metabolism . . .	=261·88 „
		=10·47 grms. N. per day per man,	
Total N. of intake . .	=394·95 „	=66·30 % of N. of diet.	

Second week.

Total intake—		Total output—	
Same.	=394·95 grms.	N. of urine	250·58 grms.
		·5 grm. per day constant . .	12·50 „
(Note the very close results from observations over each week.)		Total N. metabolism . . .	=263·08 „
		=10·52 grms. of N. per day per man,	
		=66·61 % of N. of diet.	

Diet IV.

Total intake—		Total output—	
N. of Country rice. .	78·30 grms.	N. of urine	234·08 grms.
N. of Wheat ata . .	140·40 „	·5 grm. per day constant . .	12·50 „
N. of Arhar dal . .	149·10 „		
N. of Vegetables . .	11·80 „	Total N. of metabolism . .	=246·58 „
		=9·86 grms. per day per man,	
Total N. of intake . .	=379·60 „	=64·95 % of N. of diet.	

Diet V.

Total intake—		Total output—	
N. of Country rice. .	62·40 grms.	N. of urine corrected for five men	232·03 grms.
N. of Wheat ata . .	140·40 „	·5 grm. per day constant . .	12·50 „
N. of Arhar dal . .	149·10 „		
N. of Vegetables . .	11·80 „	Total N. metabolism . . .	=244·53 „
		=9·78 grms. N. per day per man,	
Total N. of intake . .	=363·70 „	=67·23 % of N. of diet.	

From the results obtained we get the following :—

Constants.		Varying amounts of Rice.		Diet of Scheme.	Amount of nitrogenous metabolism per man daily.
		Country rice . .	16 ozs.	Diet I.	9·71 grms.
Wheat ata .	10 ozs.	,, ,, . .	14 ,,	Diet II.	10·10 ,,
Arhar dal .	6 ,,	,, ,, . .	12 ,,	Diet III.	10·49 ,,
Vegetables .	6 ,,	,, ,, . .	10 ,,	Diet IV.	9·86 ,,
		,, ,, . .	8 ,,	Diet V.	9·78 ,,

So that from this series of observations we have obtained absolute confirmation of the facts already brought out in previous investigations, *viz.*, increase of the quantity of rice (Burma or Country) beyond what we may call the optimum amount is not only not accompanied by an increase in the degree of protein metabolism, but actually by a decrease.

By plotting out these figures we obtain a curve which clearly brings out the effects on protein metabolism of a gradual increase in the quantity of rice from 8 ozs. to 16 ozs. per man daily, when the other constituents of the diet are kept constant—shown on Chart VIII.

The investigations in this series are of special importance and, from the point of view of the investigator, most satisfactory for these reasons :—

(1) The prisoners experimented upon were finely developed healthy men.

(2) They maintained their body-weight without any marked variation one way or the other.

(3) In every instance the full quantity of rice and all other elements of the daily diet were consumed. This differs very markedly from what we found in Buxar where Burma rice was in use. By a comparison of the results of the amounts of nitrogenous metabolism from these different scales of diet we get remarkable results. Thus, supposing for a moment that exactly the same amount of protein would be absorbed and undergo metabolism by the prisoners from the "constant" constituents of the diets, we would get the following results regarding the relative variations in the amount of protein absorbed from different quantities of rice :—

From 16 ozs. of rice	= 4·99 grms. N.	relatively	9·71 grms.
14 ,, ,, ,,	= 4·37 ,, N.	,,	10·10 ,,
12 ,, ,, ,,	= 3·74 ,, N.	,,	10·49 ,,
10 ,, ,, ,,	= 3·12 ,, N.	,,	9·86 ,,
8 ,, ,, ,,	= 2·49 ,, N.	,,	9·78 ,,

From these results it is at once obvious that :—

(1) The optimum absorption is obtained in a diet of the above types when the amount of rice in the diet is about twelve ozs. per day.

(2) The co-efficient of protein absorption of rice, or indeed of any of these vegetable food materials, cannot be anything approaching a constant.

(3) The amount of nitrogen absorbed from the "basal diet" our "constant" is not uniform with varying amounts of rice in the diet, for example :—

Diet III.

Constant + 3·74 N. from rice, metabolism 10·49 grms.

Diet IV.

Constant + 3·12 N. from rice, metabolism 9·86 grms.

i.e., the co-efficient of protein absorption of rice from these results is just over 100 %.

This is an impossibility and can only be explained by an accompanying increased absorption from the "basal" or "constant" part of the diet when the amount of rice is diminished.

That this increased absorption from the basal or constant part of the diet has a limit is brought out by a comparison of results of Diets III and V.

Diet III.

Constant + 3·74 N. from rice, metabolism 10·49 grms.

Diet V.

Constant + 2·49 N. from rice, metabolism 9·78 grms.

i.e., the absorptive co-efficient of the protein of rice now works out at about 57 per cent.

This is explained by the facts already shown. As the quantity of rice—given with the basal or constant part—is decreased from what we know to be the optimum amount, the loss to the body of nitrogen is made up by a greater and greater increase in the absorption of nitrogen from the basal constituents of the diet, so that after an initial fall the amount of nitrogen absorbed will remain fairly constant on reduction of rice—up to a certain limit. If this limit be exceeded, the fall in absorption will again take place.

The proof of this is well seen in a comparison of the results obtained from Diet IV and Diet V.

Diet IV.

Nitrogen of " constant " + nitrogen from 10 ozs. rice gives 9·86 grms. N. metabolism.

Diet V.

Nitrogen of " constant " + nitrogen from 8 ozs. rice gives 9·78 grms. N. metabolism.

Therefore, if the amount of nitrogen absorbed from the constant with varying quantities of rice were always the same we should have 0·63 grms. of nitrogen giving an increased absorption of only 0·08 grms. of nitrogen which is absurd.

The explanation is that in Diet V a greater percentage of the nitrogen of both " constant " and the 8 ozs. of rice is absorbed than in Diet IV.

Taking the diets where the amount of rice is beyond the optimum the reverse conditions obtain. As the rice is increased in quantity a lower and lower percentage of protein absorption takes place both from the " constant " and the varying quantities of rice. These observations afford further proof, if more evidence is required, of the impossibility of obtaining any one figure representing the absorptive co-efficient of the protein of rice, or indeed other cereals of a bulky nature when cooked, if the quantities of the food-stuffs forming the diets are high; they further show that the degree of protein absorption depends very largely on the total mass of the diet.

We would now draw attention to the very close similarity of the charts derived from the results in Buxar jail and Bhagalpur jail. In these observations where the quantities of rice given were similar in amount the charts appear to be practically identical. The Buxar chart, for reasons already mentioned, is on a lower scale. We show this comparison on Chart IX.

(ii) Investigations to determine the different degrees of nitrogenous metabolism on diets composed of country rice, wheat ata, arhar dal and vegetables—all constituents, except wheat ata of the diets, remaining constant.

TABLE XVII.

SCHEME OF DIETS.

Constants.					
Country rice	60 ozs.	+	Wheat ata	60 ozs.	=Diet I.
Arhar dal	30 ,,		,, ,,	50 ,,	=Diet II.
Vegetables	30 ,,		,, ,,	40 ,,	=Diet III.
			,, ,,	30 ,,	=Diet IV.

Diet I.

Behari prisoners observed over five consecutive days.

BATCH I.	Quantity of urine.	Total N. of urine	Weight.	N. of country rice.	N. of wheat ata.	N. of arhar dal.	N. of vege-tables.	REMARKS
	c.c.	grms.	lbs.	grms.	grms.	grms.	grms.	
Five prisoners, Beharis .	8,480	50·57	127·9	18·73	33·69	29·82	2·36	
	7,550	47·45	127·9	18·73	33·69	29·82	2·36	
	8,980	48·68	128·0	18·73	33·69	29·82	2·36	
	7,600	47·66	127·9	18·73	33·69	29·82	2·36	
	6,570	47·73	127·9	18·73	33·69	29·82	2·36	

Diet II.

BATCH II.		
Five prisoners, Beharis .	See Table XVI—Bhagalpur Jail. Diet III—Observations over ten days.	

Diet III.

BATCH II.								
Five prisoners, Beharis .	6,550	42·80	124·6	18·73	22·46	29·82	2·36	
	8,050	47·27	124·5	18·73	22·46	29·82	2·36	
	7,680	44·38	124·7	18·73	22·46	29·82	2·36	
	6,610	47·84	124·6	18·73	22·46	29·82	2·36	
	6,830	46·56	124·6	18·73	22·46	29·82	2·36	

Diet IV.

BATCH II.								
Five prisoners, Beharis .	5,810	46·01	124·6	18·73	16·84	29·82	2·36	
	6,380	44·82	124·9	18·73	16·84	29·82	2·36	
	8,600	46·24	124·7	18·73	16·84	29·82	2·36	
	6,560	43·53	124·6	18·73	16·84	29·82	2·36	
	5,620	42·09	124·6	18·73	16·84	29·82	2·36	

What do we learn regarding the different degrees of nitrogenous metabolism from this series of investigations ?

Diet I.

Total intake—
N. of Country rice . . 93·65 grms.
N. of Wheat ata . . 168·45 „
N. of Arhar dal . . 149·10 „
N. of Vegetables . . 11·80 „

Total N. of intake . . =423·00 „

Output—
N. of urine . . . 242·06 grms.
·5 grm. per day constant . 12·50 „

Total metabolism . . . =254·56 „
=60·18 % of N. of diet,
=10·18 grms. of N. per man daily.

Diet II.

Total intake of N. . . =394·95 grms.

Total output of N. in urine
+ Constant of ·5 grm. . =262·48 grms.
=64·45 % of N. of diet,
=10·49 grms. of N. per man daily.

Diet III.

Total intake—
N. of Country rice . . 93·65 grms.
N. of Wheat ata . . 112·30 „
N. of Arhar dal . . 149·10 „
N. of Vegetables . . 11·80 „

Total N. of intake . =366·85 „

Total output—
N. of urine . . . 228·85 grms.
·5 grm. N. of constant . 12·50 „

Total N. metabolism . =241·35 „
=65·78 % of N. of diet
=9·45 grms. N. per man daily.

Diet IV.

Total intake—
N. of Country rice . . 93·65 grms.
N. of Wheat ata . . 84·20 „
N. of Arhar dal . . 149·10 „
N. of Vegetables . . 11·80 „

Total N. of intake . =338·75 „

Total output—
N. of urine . . . 222·70 grms.
·5 grm. N. of constant . 12·50 „

Total N. metabolism . =235·20 „
=69·43 % of N. of diet
=9·41 grms. N. per man daily.

Therefore from this series of observations we get the following information :—

Constants of Diet.		Varying amounts of wheat ata.		Diet of Scheme.	Amount of nitrogenous metabolism per man daily.
Country rice . 12 ozs.	} + {	Wheat ata .	12 ozs.	Diet I.	10·18 grms.
Arhar dal . 6 „		„ „ .	10 „	Diet II.	10·49 „
Vegetables . 6 „		„ „ .	8 „	Diet III.	9·65 „
		„ „ .	6 „	Diet IV.	9·41 „

That is, the maximum protein absorption takes place from a diet containing 10 ozs. of wheat ata per day, the other constituents of the diet being constant at rice 12 ozs., arhar dal 6 ozs., vegetables 6 ozs., while the amount of wheat ata varies in the different diets from 6 ozs. to 12 ozs. per man daily.

By plotting out these figures we obtain the curve showing the effects on protein metabolism of this gradual increase in the quantity of wheat ata from 6 ozs. to 12 ozs. per man per day. This is shown in Chart X.

By contrasting the charts of this series of observations in Buxar and Bhagalpur jails—Charts IV and X—it will be seen that the level of nitrogenous metabolism is lower in Buxar jail and that, while the curves do not exactly correspond with each other, they have much the same features.

The quantity of wheat ata in the Buxar diet which gave the maximum absorption we found lay between 8 and 10 ozs. and, from the closeness of the figures for these amounts, we decided it was 9 ozs. In the Bhagalpur diet the chart shows 10 ozs. of wheat ata as giving the maximum absorption, but no observation was made with 9 ozs. of wheat ata in the diet; so it is quite possible that the amounts may be identical for the two jails. At all events, we are justified in concluding that, with diets of the Behari type, the most advantageous combination appears to be:—

Burma or Country rice	12 ozs.
Wheat ata	9 or 10 ozs.
Different dals	6 ozs.
Vegetables	6 ,,

Both charts agree in showing there is nothing to be gained by increasing the amount of wheat ata to more than 10 ozs. per man daily.

(iii) Investigation to determine the different degrees of nitrogenous metabolism on diets composed of country rice, makkai ata, arhar dal and vegetables—all constituents of the diets, except country rice, remaining constant in quantity.

TABLE XVIII.

Scheme of Diets.

Constants.					
			Country rice	80 ozs.	=Diet I.
Makkai ata	60 ozs.	+	,, ,,	70 ,,	=Diet II.
Arhar dal	30 ,,	+	,, ,,	60 ,,	=Diet III.
Vegetables	30 ,,	+	,, ,,	50 ,,	=Diet IV.
			,, ,,	40 ,,	=Diet V

Diet I.

Behari prisoners observed over five consecutive days.

Batch B.	Quantity of Urine.	Total N. of Urine.	Weight.	N. of Country rice.	N. of Makkai ata.	N. of Arhar dal.	N. of Vegetables.
	c.c.	grms.	lbs.	grms.	grms.	grms.	grms.
Ten prisoners, Beharis.	16,560	88·21	121·2	49·95	50·04	59·64	4·72
	19,130	90·80	—	49·95	50·04	59·64	4·72
	15,790	85·77	—	49·95	50·04	59·64	4·72
	17,420	90·49	—	49·95	50·04	59·64	4·72
	18,740	93·77	121·2	49·95	50·04	59·74	4·72

Diet II.

Batch III.							
Five prisoners, Beharis.	6,090	40·02	120·4	21·85	23·54	29·82	2·36
	7,320	42·63	—	21·85	23·54	29·82	2·36
	6,130	40·59	120·4	21·85	23·54	29·82	2·36
	6,400	41·66	—	21·85	23·54	29·82	2·36
	7,560	45·40	120·4	21·85	23·54	29·82	2·36

Only 55 ozs. of makkai ata were eaten on the average daily on this diet.

Diet III.

Batch IV.							
Five prisoners, Beharis.	8,890	45·53	122·7	18·73	25·04	29·82	2·36
	7,030	45 42	122·6	18·73	25·04	29·82	2·36
	7,510	46·40	122·8	18·73	25·04	29·82	2·36
	8,660	46 07	122·8	18·73	25·04	29·82	2·36
	10,850	46·24	122·7	18·73	25·04	29·82	2·36

Diet IV.

Batch III.	Quantity of Urine.	Total N. of Urine.	Weight.	N. of Country rice.	N. of Makkai ata.	N. of Arhar dal.	N. of Vegetables.
Five prisoners, Beharis.	7,300	41·69	121·1	15·66	25·02	29·82	2·36
	6,120	42·41	121·3	15·66	25·02	29·82	2·36
	6,740	43·87	121·2	15·66	25·02	29·82	2·36
	5,860	38·55	121·2	15·66	25·02	29·82	2·36
	6,000	41·45	121·1	15·66	25·02	29·82	2·36

Diet V.

Five prisoners, Beharis.	7,770	40·13	121·1	12·48	25·02	29·82	2·36
	7,340	41·61	121·2	12·48	25·02	29·82	2·36
	6,620	41·92	121·2	12·48	25·02	29·82	2·36
	6,810	38·80	121·1	12·48	25·02	29·82	2·36
	7,040	42·49	121·1	12·48	25·02	29·82	2·36

What do we learn regarding the protein metabolism going on with these different diets?

Diet I.

Total intake of N. . . =821·75 grms. Total nitrogenous metabolism . =471·04 grms.
=57·32 % of N. of diet
=or 9·42 grms. N. per man daily.

Diet II.

Total intake of N. . . =387·85 grms.

Output—
N. of urine . . . . . 210·30 grms.
·5 grm. constant . . . 12·50 „

Total N. metabolism . . . =222·80 „
=57·47 % of N. of diet
=8·91 grms. N. per man daily.

Diet III.

Total intake of N. . . =379·75 grms.

Output—
N. of urine . . . . . 229·66 grms.
·5 grm. constant . . . 12·50 „

Total N. metabolism . . =241·16 „
=63·76 % of N. of diet
=9·68 grms. N. per man daily.

Diet IV.

Total intake of N. . . =363·30 grms.

Output—	
N. of urine	207·97 grms.
·5 grm. constant . . .	12·50 ,,
Total N. metabolism . .	=220·47 ,,
=60·68 % of N. of diet	
=8·82 grms. per man daily.	

Diet V.

Total N. of intake . . =348·40 grms.

Total output—	
N. of urine	204·96 grms.
·5 grm. per day constant .	12·50 ,,
Total N. metabolism . .	=217·46 ,,
=62·13 % of N. of diet	
=8·69 grms. N. per man daily.	

From these investigations we get the following results per man :—

Constants of Diets.		Varying amounts of Country rice.	Diet of Scheme.	Amount of N. metabolised per man daily.
Makkai ata . 12 ozs.	+	Country rice . 16 ozs.	=Diet I.	9·42 grms.
Arhar dal . 6 ,,		,, ,, . 14 ,,	=Diet II.*	8·91 ,,
Vegetables . 6 ,,		,, ,, . 12 ,,	=Diet III.	9·68 ,,
		,, ,, . 10 ,,	=Diet IV.	8·82 ,,
		,, ,, . 8 ,,	=Diet V.	8·69 ,,

The series shows that the best absorption is obtained from a diet in which Country rice 12 ozs. per man daily is given, thus again confirming the results obtained in the other series of experiments to determine the optimum amount of rice for a diet of the above type.

Chart XI gives the results shown in a graphic manner ; in regard to the diet containing 14 ozs. of rice, only 11 ozs. of makkai ata were consumed which rather spoils the chart, but, leaving this entirely aside, the fall with 16 ozs. confirms the former results that 12 ozs. of rice—Burma or Country—is the optimum quantity, whether in combination with 10 ozs. of wheat ata or 12 ozs. of makkai ata.

In Chart XI*a* we contrast the curves plotted out from the results of the same series in Bhagulpur jail and Buxar jail. It will be evident that they present practically the same features of importance. The Bhagulpur results are on a higher level of nitrogenous metabolism due largely to the prisoners in that jail being able to consume and make use of 12 ozs. of makkai while those in Buxar could only eat 10 ozs.

* In this diet the makkai ata was not constant and averaged 11 ozs. per man daily instead of 12 ozs.

(iv) Investigations to determine the degrees of nitrogenous metabolism on diet composed of country rice, makkai ata, arhar dal and vegetables—all constituents of the diet except makkai ata, remaining constant.

TABLE XIX.

SCHEME OF DIETS.

Constants.			Varying quantities of makkai ata.		
Country rice . .	60 ozs.	+	Makkai ata . .	60 ozs.	=Diet I.
Arhar dal . .	30 ,,		,, ,, . .	50 ,,	=Diet II.
Vegetables . .	30 ,,		,, ,, . .	40 ,,	=Diet III.

Diet I.

Five Behari prisoners observed over five consecutive days.

BATCH IV.	Quantity of Urine.	Total N. of Urine.	Weight.	N. of Country rice.	N. of Makkai ata.	N. of Arhar dal.	N. of Vege-tables.
	c.c.	grms.	lbs.	grms.	grms.	grms.	grms.
Five prisoners, Beharis.	8,590	45·53	122·6	18·73	25·02	29·82	2·36
	7,030	45·42	122·6	18·73	25·02	29·82	2·36
	7,510	46·40	122·8	18·73	25·02	29·82	2·36
	8,660	46·07	122·7	18·73	25·02	29·82	2·36
	10,850	46·24	122·6	18·73	25·02	29·82	2·36

Diet II.

BATCH IV.							
Five prisoners, Beharis.	9,100	42·92	122·9	18·73	20·85	29·82	2·36
	8,710	42·92	122·9	18·73	20·85	29·82	2·36
	8,130	40·29	123·1	18·73	20·85	29·82	2·36
	8,890	42·06	123·1	18·73	20·85	29·82	2·36
	8,580	42·04	123	18·73	20·85	29·82	2·36

Diet III.

Batch IV.	Quantity of Urine.	Total N. of Urine.	Weight.	N. of Country rice.	N. of Makkai ata.	N. of Arhar Dal.	N. of Vegetables.
	c.c.	grms.	lbs.	grms.	grms.	grms.	grms.
Five prisoners, Beharis .	7,820	41·27	123·9	18·73	16·68	29·82	2·36
	8,200	40·63	123·7	18·73	16·68	29·82	2·36
	10,350	42·74	123·9	18·73	16·68	29·82	2·36
	8,210	40·91	124·0	18·73	16·68	29·82	2·36
	7,550	41·01	124·0	18·73	16·68	29·82	2·36

What do we learn regarding the protein metabolism from this series ?

Diet I.

Total intake of nitrogen. = 379·75 grms.

Total output—

N. of urine	229·66 grms.
·5 grm. constant . . .	12·50 ,,
Total N. metabolism . .	= 242·16 ,,

= 63·76 % of N. of diet
= 9·68 grms. N. per man daily.

Diet II.

Total intake of nitrogen. = 358·80 grms.

Total output—

N. of urine	210·23 grms.
·5 grm. per day constant .	12·50 ,,
Total N. metabolism . .	= 222·73 ,,

= 62·07 % of N. of diet
= 8·91 grms. of N. per man daily.

Diet III.

Total intake of nitrogen. = 337·95 grms.

Total output—

N. of urine	206·56 grms.
·5 grm. per day constant .	12·50 ,,
Total N. metabolism . .	= 219·06 ,,

= 64·82 % of N. of diet
= 8·76 grms. N. per man daily.

We, therefore, get the following results :—

Constants.			Varying amounts of makkai ata.		Diet of scheme.	Amount of nitrogenous metabolism per man daily.
Country rice .	12 ozs.	+	Makkai ata .	12 ozs.	Diet I.	9·68 grms.
Arhar dal .	6 ,,		,, ,, .	10 ,,	Diet II.	8·91 ,,
Vegetables .	6 ,,		,, ,, .	8 ,,	Diet III.	8·76 ,,

It would, therefore, appear that up to 12 ozs. of makkai ata may be taken with advantage in combination with 12 ozs. rice and the usual dal and vegetables. But it is almost impossible to get 12 ozs. of makkai eaten for more than a few days at a time : even in Bhagulpur we had difficulty in having the full ration taken.

We may conclude, therefore, that 12 ozs. of makkai is about the maximum amount the prisoners will consume voluntarily ; and our results show that it is not beyond the amount from which the maximum absorption, in a diet of the above type, is able to take place. The 12 ozs. of makkai ata sanctioned in the jail code is about right if the quantity of rice be reduced to 12 ozs. per man daily.

The effect of substituting makkai ata 12 ozs. for wheat ata 10 ozs. in Bhagulpur jail is shown on Chart XII. The results obtained corroborate what we found in the Buxar investigations, *viz.*, it had the effect of placing the prisoners on a lower plane of nitrogenous metabolism. The average decrease in the amount of nitrogen undergoing metabolism from this substitution is not so great as in Buxar jail—in Buxar jail it was 1·66 grms. nitrogen whereas in Bhagulpur jail it is under 1 grm. However, the prisoners in Bhagulpur jail were getting 12 ozs. of makkai, while the Buxar prisoners only got 10 ozs.

This concludes our observations on the effects of varying the quantities of wheat ata and makkai ata, Burma rice and Country rice in the two jails of Behar.

The results obtained are very definite and clear. While certain variations are met with, due to accidental or experimental errors, the main features of the curves obtained under similar conditions are very closely identical.

We claim to have proved from these investigations that the quantity of rice—Burma or Country—in the Behari diet is too great ; and that, whether given with wheat ata or makkai ata, it can be reduced to 12 ozs. per man daily. The advantages of this reduction are clearly brought out in the charts and do not require any further discussion. Further, we have shown that 10 ozs. of wheat ata per man daily, and from 10 to 12 ozs. of makkai ata are the optima amounts to be used in combination with 12 ozs. of rice.

There now remains the question of the amount of dal, when given along with these quantities of rice and wheat or makkai ata, from which the best results are to be obtained. We have seen from the investigations recorded on Table XIII that with a diet composed of 12 ozs. Burma rice, 12 ozs. wheat ata, and 6 ozs. of different dals very similar amounts of protein absorption took place whether the dal was highly nitrogenous or only fairly so. This is evidence that the nitrogen of the highly nitrogenous dals is not absorbed so well as that of the dals offering less nitrogen in the diets, and that, therefore, the amount of nitrogen offered in the form of dal for that type of diet could be decreased with advantage, *i.e.*, would

leave less residue for intestinal putrefaction. While this is true with regard to a diet containing 12 ozs. of wheat ata, will it be the case when the wheat ata is reduced to 10 ozs. per man daily ?

The question, therefore, is :—accepting our result as correct, that the proper quantities for a diet of the Behar type are 12 ozs. of Burma or Country rice, 10 ozs. of wheat ata or 12 ozs. of makkai ata, what amount of dal should be given with these constituents in order that the absorption should be a maximum ? In order to answer this question the following investigations were carried out.

To keep the conditions as nearly constant as possible arhar dal was experimented with in Bhagulpur jail, and mung dal in Buxar jail. Mung dal is a representative of the more highly nitrogenous forms, while arhar contains the medium percentage of protein. Both forms are favourite dals with the Behari. They may be, therefore, taken as fairly representative of the general run of dals in use.

(i) Investigations to obtain the varying degrees of nitrogenous metabolism on diets of country rice, wheat ata, arhar dal and vegetables—when all constituents of the diets are constant, except the arhar dal.

Bhagalpur Jail.

TABLE XX.

SCHEME OF DIETS.

CONSTANTS.				
Country rice . . . 60 ozs.	+	Arhar dal .	35 ozs.	Diet I.
Wheat ata . . . 50 „		„ „ .	30 „	Diet II.
Vegetables . . . 30 „		„ „ .	25 „	Diet III.

Diet I.

Behari prisoners observed for five consecutive days.

BATCH V.	Quantity of Urine.	Total N. of Urine.	Weight.	N. of Country rice.	N. of Wheat ata.	N. of Arhar dal.	N. of Vegetables.
	c.c.	grms.	lbs.	grms.	grms.	grms.	grms.
Five prisoners, Beharis .	7,070	49·78	129·8	18·73	28·08	34·79	2·36
	7,750	50·99	129·7	18·73	28·08	34·79	2·36
	7,000	45·59	..	18·73	28·08	34·79	2·36
	8,240	50·23	..	18·73	28·08	34·79	2·36
	7,180	50·04	129·8	18·73	28·08	34·79	2·36

Diet II.

Batch II.	Quantity of Urine.	Total N. of Urine.	Weight.	N. of Country rice.	N. of Wheat ata.	N. of Arhar dal.	N. of Vegetable.
	c.c.	grms.	lbs.	grms.	grms.	grms.	grms.
Five prisoners, Beharis .		See Table XVI—Bhagulpur Diet III. Average for 10 days' observation.					

Diet III.

Batch V.	Quantity of Urine.	Total N. of Urine.	Weight.	N. of Country rice.	N. of Wheat ata.	N. of Arhar dal.	N. of Vegetable.
Five prisoners, Beharis .	7,630	48·17	129·9	18·73	28·08	24·85	2·36
	6,300	46·92	..	18·73	28·08	24·85	2·36
	6,530	44·43	..	18·73	28·08	24·85	2·36
	7,250	46·99	..	18·73	28·08	24·85	2·36
	4,400	41·84	129·9	18·73	28·08	24·85	2·36

What do we learn from this series of investigations ?

Diet I.

Total intake of nitrogen . =419·80 grms. Total output—

N. of urine . . . 246·63 grms

·5 grm. per day constant . 12·50 ,,

Total N. metabolism . . =259·13 ,,

=61·72 per cent. of N. of diet

=10·28 grms. of N. per man daily.

Diet II.

(See Table XVI—Bhagulpur.)

Total N. of intake . . =394·95 grms. Total N. metabolism . =262·48 grms

= 66·45 per cent. of N. of diet

= 10·49 grms. of N. per man daily.

Diet III.

Total N. of intake . =370·10 grms. Total output—

N. of urine . . . . . 228·35 grms

·5 grm N. daily constant . 12·50 ,,

Total N. metabolism . . =240·85 ,,

=65·07 per cent. of N. of diet

= 9·63 grms. N. per man daily.

We, therefore, get the following information from this series—

Constants.		Varying amounts of Arhar dal.		Diet of scheme.	Amount of N. metabolism per man daily.
Country rice	12 ozs.	Arhar dal	7 ozs.	Diet I.	10·28 grms.
Wheat ata	10 ,,	,, ,,	6 ,,	Diet II.	10·49 ,,
Vegetables	6 ,,	,, ,,	5 ,,	Diet III.	9·63 ,,

That is, we have evidence that an increase in the quantity of arhar dal of the prisoners' diet scale is not accompanied by an increase—but by a diminution—in the actual quantity of protein absorbed and assimilated from the diet. We further learn that the quantity sanctioned for the jail diet is the amount from which the maximum absorption takes place—that is, when combined with the quantities of rice and wheat ata from which we obtained the maximum absorption—12 ozs. of rice and 10 ozs. wheat ata.

It is quite possible and highly probable that other combinations of rice, wheat or makkai ata dal could have been obtained from which an equally good absorption of protein would have followed: as for instance one containing

14 ozs. of rice, 10 ,, of wheat ata, 4 ,, different dals, 6 ,, vegetables,	or	14 ozs. rice, 12 ,, of makkai ata, 4 ,, of arhar dal, 6 ,, of vegetables,

but, while combinations such as these are possible and worthy of investigation, we were guided in our researches by what was observed during the dieting experiments. As before stated, it was with difficulty that we could get 16 ozs. of Country rice eaten, and impossible to get 16 ozs. of Burma rice consumed by prisoners. It therefore appeared a clear indication that rice was the part of the diet in excess of requirements, especially as there never was any difficulty in getting the 10 ozs. of wheat ata or 6 ozs. of dal daily completely consumed. Although 12 ozs. of makkai ata were eaten in the majority of experiments in Bhagulpur—where that amount was given—it was always with some difficulty that we got it consumed for seven days consecutively, and therefore increase in its amount is not practicable.

Another point to which we may draw attention and one that affords further evidence that the quantities of rice, wheat ata and dal, which we have suggested are those from which the best absorption will take place, is the high co-efficient of absorption obtained for the protein of arhar dal when Diets II and III of this table are contrasted. Thus—

Diet II—protein absorption from constant + that from 6 ozs. Arhar dal gives 10·49 grms. nitrogen per man daily.

Diet III—protein absorption from constant + that from 5 ozs. Arhar dal gives 9·63 grms. nitrogen per man daily.

Now, assuming that the amount of protein absorption from the constant part of these diets is the same in both—this is probably a correct assumption as the decrease in bulk due to one oz. of arhar dal would have little effect, and is quite different from a reduction in the much more bulky rice—we see that an increase of one oz. of arhar dal causes an increased protein metabolism from 9·63 grms. to 10·49 grms. nitrogen.

This works out at an absorption of the protein of arhar dal of just over 85 per cent.; a figure closely approaching the normal to be expected for a fairly digestible vegetable protein.

Exactly similar results were obtained in Buxar jail by reducing the mung dal from 6 ozs. to 5 ozs. and finally to 4 ozs. per man daily—when the diet consisted otherwise of Burma rice 12 ozs., wheat ata 10 ozs. and 6 ozs. of vegetables. A steady fall in the level of nitrogenous metabolism took place; so that we may accept it that the 6 ozs. of dals sanctioned in the jail dietaries is the correct amount, when given in combination with the optimum amount of Burma or Country rice and wheat or makkai ata.

(ii) Investigation to obtain the varying degrees of nitrogenous metabolism on diets of Burma rice, wheat ata, mung dal and vegetables—when all constituents of the diets are constant, except the mung dal.

Buxar Jail.

TABLE XXI.

SCHEME OF DIETS.

Constants.			Varying amounts of mung dal.		
Burma rice	12 ozs.	+	Mung dal	6 ozs.	Diet I.
Wheat ata	10 „		„ „	5 „	Diet II.
Vegetables	6 „		„ „	4 „	Diet III.

Diet I.

Behari prisoners observed for five consecutive days.

	Intake of nitrogen	=425·50	grms.
See Table XI, Diet III, Buxar Jail	Output of nitrogen	=251·15	„
=59·02 per cent. of N. of diet		= 10·05	„ N. per man daily.

Diet II.

Batch V.	Quantity of Urine.	Total N. of Urine.	N. of Burma rice.	N. of Wheat ata.	N. of Mung dal.	N. of Vegetables.	Weight of prisoners.
	c.c.	grms.	grms.	grms.	grms.	grms.	lbs.
Five prisoners, Beharis .	6,300	41·55	20·40	27·75	28·82	2·36	107·4
	6,620	44·75	20·40	27·75	28·82	2·36	107·6
	6,690	39 28	20·40	27·75	28·82	2·36	107·6
	6,600	41·29	20·40	27·75	28·82	2·36	107·5
	5,720	47·80	20·40	27·75	28·82	2·36	107·4

Diet III.

Five prisoners, Beharis .	4,560	38·38	20·40	27·75	23·06	2·36	107·2
	5,030	36·72	20·40	27·75	23·06	2·36	107·2
	5,000	38·77	20·40	27·75	23·06	2·36	107·3
	6,500	39·58	20·40	27·75	23·06	2·36	107·2
	6,000	35·95	20·40	27·75	23·06	2·36	107·2

What do we learn from this series ?

Diet I.

Total nitrogen intake . = 425·50 grms. Total output=251·15 grms.
=59·02 per cent. of the nitrogen of the diet
or 10·05 grms. of nitrogen per man daily.

Diet II.

Total nitrogen intake . = 396·65 grms. Total output—

N. of urine	214·67 grms.
5 grm. daily constant . . .	12·50 „
Total N. metabolism . . .	227·17 „

=57·27 per cent. of the total nitrogen of the diet.
= 9·09 grms. of nitrogen per man daily.

Diet III.

Total nitrogen intake .	=367·80 grms.	Total output—	
		N. of urine	189·40 grms.
		·5 grm. daily constant . . .	12·50 „
		Total N. metabolism . . .	201·90 „
		=54·89 per cent. of the nitrogen of the diet.	
		=8·08 grms. of nitrogen per man daily.	

Therefore, we obtain the following information :—

Constants.		Varying amounts of mung dal.		Grms. of nitrogenous metabolism per man daily.
Burma rice . 12 ozs.	+	Mung dal . 6 ozs.	Diet I.	10·05
Wheat ata . 10 „		„ „ . 5 „	Diet II.	9·09
Vegetables . 6 „		„ „ . 4 „	Diet III.	8·08

Again showing that the maximum absorption is obtained from a diet consisting of 12 ozs. Burma rice, 10 ozs. wheat ata, 6 ozs. vegetables when 6 ozs. of mung dal is given, and that a reduction of the amount of dal is followed by a corresponding reduction in the quantity of nitrogen absorbed. We give on Chart XIII the figures for the varying amounts of mung and arhar dals plotted out to show the effects graphically.

By working out the percentage protein absorption of mung dal from the diets given on Table XXI it will be found to average 85 per cent.—a much higher figure than can be obtained when the quantities of rice in the diet are greater than 12 ozs. per man daily.

As we have already pointed out this may not be entirely due to a high protein absorption from the dal alone—although in this particular type of diet it probably is. In all likelihood an increased absorption takes place from the constants of the diets so that a seemingly greater increase occurs from the varying constituents than is really the case; this is particularly the case when we are dealing with a bulky material like rice as the varying constituent of the diet.

This finishes all we have to say regarding section (3) or the effects of varying the quantities of the components of the Behari type of diet.

It will be evident from a comparison of these results with those obtained from the dietaries of lower Bengal jails that the Behari is on a higher level of nitrogenous metabolism, and in accordance with this we find his physical development, body weight, and general capabilities of performing work and resisting infection also on a higher level. The great defect of the Behar jail diet is the same as that of the lower Bengal diet—the large residue left over to be dealt with by the bowel with all its attendant disabilities. It is not therefore to be wondered at that intestinal troubles are very prevalent amongst the Beharis as well as amongst the Bengalis and Ooriyas.

The general conclusion arrived at from these investigations is the urgent necessity for a reduction in the quantities of rice given to the prisoners, both in the interests of their health and from motives of economy.

The quantity of rice in the Bengal jail diets should be reduced by 8 ozs. per man daily, and in Behar diets by 4 ozs. per man daily. We have no hesitation in saying that, in effecting this economy to the State, the prisoners will be placed in a much better position as regards their nutrition, capabilities of doing work and general health.

We now pass to some observations made on the effects of adding an animal protein to the Behari diet; but, as the level of nitrogenous metabolism is already high we did not consider it necessary to go into much detail regarding these effects.

SECTION 4.

The effects of varying the components of the Behari diet, *i.e.*, of adding an animal protein to it.

TABLE XXII.

Buxar Jail.

(i) Investigations to determine the percentage of the nitrogen of mutton absorbed when mutton is added to a diet in which the level of nitrogenous metabolism is on a low scale.

Diet A.

Five Behari prisoners on "basal diet" for a week.

Batch Q.	Quantity of Urine.	Total N. of Urine.	Weight of prisoners.	N. of Burma rice.	N. of Mung dal.	N. of Makkai ata.	N. of Goat's flesh.	N. of Vegetables.
	c.c.	grms.	lbs.	grms.	grms.	grms.	grms.	grms.
Five prisoners, Beharis	8,540	38·25	124·4	13·60	34·59	22·05	..	2·36
	8,880	34·18	124·4	13·60	34·59	22·05	..	2·36
	9,130	36·93	124·4	13·60	34·59	22·05	..	2·36
	10,370	35·27	124·4	13·60	34·59	22·05	..	2·36
	8,720	35·64	124·4	13·60	34·59	22·05	..	2·36

Same five men on "basal diet" to which mutton is added.

Diet B.

Batch Q, same five men	7,240	47·66	123·8	13·60	34·59	22·05	10·43	2·36
	7,000	42·67	123·6	13·60	34·59	22·05	10·43	2·36
	9,820	46·33	123·9	13·60	34·59	22·05	10·43	2·36
	9,710	44·38	124·0	13·60	34·59	22·05	10·43	2·36
	9,000	44·85	123·8	13·60	34·59	22·05	10·43	2·36

Diet A.

Total intake—		Total output of nitrogen—	
N. of Burma rice . .	68·00 grms.	N. of urine . . .	=180·27 grms
N. of mung dal . .	172·95 ,,	·5 grm. of N. daily constant .	= 12·50 ,,
N. of makkai ata . .	110·25 ,,		
N. of vegetables . .	11·80 ,,	Total N. metabolism . .	=192·77 ,,
		=53·10 per cent. of N. of diet	
Total N. of intake .	=363·00 ,,	= 7·71 grms. N. per man daily.	

Diet B.

Total intake same as A .	=363·00 grms.	Total output of nitrogen—	
Add N. of mutton .	= 52·15 ,,	N. of urine . . .	=225·89 grms.
		·5 grm. of N. daily constant	= 12·50 ,,
Total N. of intake	=415·15 ,,		
		Total N. metabolism	=238·39 ,,
		=57·42 per cent. of N. of diet	
		= 9·53 grms. N. per man daily.	

Now if we falsely assume, as has always hitherto been done in investigations carried out to obtain the co-efficient of absorption of the nitrogen of different food-stuffs in European diets, that the same amount of nitrogen will be absorbed from the basal part of these Diets A and B, *i.e.*, that the same quantity of nitrogen will be absorbed from Diet A as will be absorbed from the basal part of Diet B (Diet B=Diet A+mutton) we can, by the method employed in Europe and America, obtain a figure representing the percentage of the nitrogen of the mutton that is absorbed.

From Diet A we get an absorption of 192·77 grms. nitrogen.
From Diet A + mutton (B) absorption of 238·39 grms. nitrogen.

Therefore, on above assumption—

52·15 grms. nitrogen of mutton gives an absorption of 45·62 grms. or 87·47 per cent.

So that, on the above assumption the nitrogen of goat's flesh is absorbed to an extent of 87·47 per cent.; but, while this percentage is true for these particular experiments, it does not hold good in other experiments where the basal part of the diet is made up differently. In other words, the figure representing the percentage of protein of mutton absorbed, obtained from experiments carried out in this way, depends very largely on how the basal diet is made up. The protein of mutton is very much more easily assimilated than is the protein of either rice, dal or ata ; and therefore on adding mutton to a basal diet, although we get an increase in the amount of protein absorbed and undergoing metabolism, the increased output of nitrogen in the urine is not a measure of the amount of protein absorbed from the mutton. It may vary in two different ways :—

1. It may happen to be the measure of the amount of nitrogen absorbed from

the mutton, *i.e.*, the amount of protein absorbed from the basal diet remains constant, whether basal diet alone is given or basal diet *plus* mutton. From the evidence we have obtained this is only likely to occur when the basal diet provides an absorption of protein that approaches the lower limits of nitrogenous equilibrium, and is of a bulk less than that likely to interfere with absorption by its size alone.

2. What is far more likely to happen is that, the protein of mutton or other meat or fish being much more easily assimilated, the intestinal canal absorbs this protein readily and allows a much larger part, than when no animal protein is present, of the protein of the basal diet to pass out unabsorbed. We have already given a good deal of evidence that this is the case, and shall rest content with stating one example of it on the Behari type of diet.

(ii) Investigations to determine the percentage of the nitrogen of mutton absorbed when the mutton is added to a diet that approaches the lower limits of nitrogenous equilibrium.

Diet =
- Burma rice . . . . 60 ozs.
- Makkai ata . . . . 40 „
- Mung dal . . . . 30 „
- Vegetables . . . . 30 „

Diet I.

Five Behari prisoners on low nitrogenous diet for a week.

BATCH S.	Quantity of Urine.	Total N. of Urine.	Weight of prisoners.	N. of Burma rice.	N. of makkai ata.	N. of Mung dal.	N. of vegetables.	N. of goat's flesh.
	c.c.	grms.	lbs.	grms.	grms.	grms.	grms.	grms.
Five prisoners, Beharis . .	9,560	35·75	117·2	20·40	17·64	34·59	2·36	..
	7,620	34·78	117·2	20·40	17·64	34·59	2·36	..
	9,820	41·45	..	20·40	17·64	34·59	2·36	..
	9,400	35·79	..	20·40	17·64	34·59	2·36	..
	12,440	43·71	117·2	20·40	17·64	34·59	2.36	..

Diet II = + Goat's flesh 16 ozs.
- Burma rice . . . . . 50 ozs.
- Makkai ata . . . . . 40 „
- Mung dal . . . . . . 30 „
- Vegetables . . . . . 30 „

Diet II.

Batch C.	Quantity of Urine.	Total N. of Urine.	Weight of prisoners.	N. of Burma rice.	N. of makkai atta.	N. of Mung dal.	N. of vegetables.	N. of goat's flesh.
Five prisoners, Beharis . .	10,530	47·32	123·6	17·00	17·64	34·59	2·36	10·43
	8,600	46·95	123·8	17·00	17·64	34·59	2·36	10·43
	10,790	46·54	123·7	17·00	17·64	34·59	2·36	10·43
	11,850	46·78	123·6	17·00	17·64	34·59	2·36	10·43
	9,170	48·07	123·6	17·00	17·64	34·59	2·36	10·43

Diet I.

Total intake of nitrogen . =374·95 grms.

Total output—
N. in urine . . . . 191·48 grms.
·5 grm. N. daily . . . 12·50 „

Total N. metabolism . . . 203·98 „
=54·40 per cent. of N. of diet
= 8·15 grms. of N. per man daily.

Diet II.

Total intake of nitrogen . =410·10 grms.

Total output—
N. of urine . . . . 225·66 grms.
·5 grm. daily . . . . 12·50 „

Total N. metabolism . . . 248·16 „
=60·51 per cent. of N. of diet
= 9·92 grms. of N. per man daily.

From these investigations we see that —

from Diet I 203·98 grms. of nitrogen undergo metabolism,
from Diet II 248·16 grms. of nitrogen undergo metabolism
now Diet II is made up of Diet I + 16 ozs. of mutton + 10 ozs. of Burma rice,

and we know from previous work that a diminution of 10 ozs. of Burma rice in a diet of the above type makes very little difference in the amount of nitrogen absorbed, particularly when the diminution of nitrogen in rice is counterbalanced by a more easily absorbed nitrogen in the form of meat. We may, therefore, take it that the increased output is largely due to the presence of mutton in the diet. Therefore 248·16 grms. − 203·98 grms. = 44·18 grms. is practically derived from 52·15 grms. N. of mutton = about 84·71 per cent. of the N. of mutton absorbed.

This is fairly close to the result already obtained in the previous investigation, and would probably be still closer if we could make allowance for the effect of the diminution of the Burma rice of the diet by 10 ozs. per day for the batch of five men.

We therefore find from this line of experiment that the addition of a certain small amount of animal diet *does* cause a large increase in the absorption of nitrogen from the diet. But, as we shall see in the next observation, this increase is by no means constant even for the addition of the same amount of meat, and that it also depends largely on the composition of the "basal diet" to which the meat is added.

(iii) Investigations to show that the increase in the amount of nitrogenous metabolism may be no real measure of the amount absorbed from a highly assimilable form of protein which has been added to a "basal" diet.

Thus, taking the diet—

Burma rice	40 ozs.	as the basal diet for five Behar prisoners,
Wheat ata	50 ,,	
Mung dal	30 ,,	
Vegetables	30 ,,	

we have seen by Table XI, Diet V, that this diet affords an intake of 391·50 grms. nitrogen of which 233·73 grms. nitrogen are absorbed.

Now to this "basal" diet were added 16 ozs. of goat's flesh when the following results were obtained :—

Batch P.	Quantity of Urine.	Weight.	Total N. of Urine.	N. of Burma rice.	N. of Mung dal.	N. of Wheat ata.	N. of Vegetables.	N. of Goat's flesh.
	c.c.	lbs.	grms.	grms.	grms.	grms.	grms.	grms.
Five prisoners, Beharis .	7,820	117·8	48·51	13·60	34·59	27·75	2·36	10·43
	8,100	117·7	50·22	13·60	34·59	27·75	2·36	10·43
	9,930	117·8	47·54	13·60	34·59	27·75	2·36	10·43
	10,480	118·0	49·65	13·60	34·59	27·75	2·36	10·43
	8,500	117·8	48·99	13·60	34·49	27·75	2·36	10·43

Total intake of nitrogen. = 443·65 grms.

Total output—

N. of Urine . . .	=244·91 grms.
·5 grm. daily . . .	= 12·50 ,,
Total N. metabolism . .	=257·41 ,,

257·41 grms.—233·73 grms.=23·68 grms. is all that would appear to be absorbed from 52·15 grms. of nitrogen in the form of mutton—only 45·40 per cent. of its nitrogen, which is absurd.

What has happened is that more of the protein of the wheat ata, rice and dal has passed out unabsorbed which causes a seemingly very low absorption of the protein of mutton. In order, therefore, to be able to show by this method anything like a normal absorption of an animal protein when added to a purely vegetable diet, the bulk of the diet must not interfere, and the level of nitrogenous absorption from the vegetable part of the diet must not be high.

Summary of Section 4.

There is no necessity to add an animal protein to a diet of the Behari type. The level of protein metabolism is already high, fully two grammes of nitrogen superior in the case of the wheat diet to that of prisoners in Lower Bengal, and we do not consider it necessary to further increase it. On the other hand, if arrangements could be made for the substitution of fish twice a week in place of part of the dal and ata, we believe it would be to the advantage of the prisoners' health. This we would only recommend for prisoners in those jails where a local supply of fish is easily and cheaply obtainable. In Buxar and Bhagulpur jails it would be a fairly simple matter to have a supply of fish procured by prison labour from the Ganges which is within easy distance from the jails. If this could be done an economy could be effected by the saving of the dal, wheat or makkai ata twice a week, and, at the same time, the monotony of the prison fare would be relieved. We think that the suggestion is important, more particularly for the large central jails where long-term prisoners are confined, and where plenty of cheap labour is available.

If it were found feasible we would recommend that the wheat or makkai ata be reduced in proportion to the amount of protein available from the fish.

Also the question of the quantity of dal must be taken into consideration. We have shown 6 ozs. of dal to be the maximum amount that can be given ; but there is no necessity to give this maximum. Reference to Tables XX and XXI will show that, with the amount of dal reduced from 6 ozs. to 5 ozs. the protein metabolism of the prisoners is on a higher level than obtains when the full quantities of the constituents of the present diet is consumed. Further, there is no doubt that dal in any form has a decided tendency to produce diarrhœa and intestinal disorders, and that the 6 ozs. of the jail diet is a far larger quantity than is consumed by the civil population of the district.

We would, therefore, recommend a diet of the following types :—

Burma or country rice	12 ozs.	
Wheat ata	10 ,,	or makkai ata 12 ozs.
Different dal in use	5 ,,	
Vegetables	6 ,,	

This might be looked on as the general scale of Behari diet.

With fish available, if it be found economical we would suggest that 5 ozs. of fish be given twice a week, replacing 2 ozs. of wheat or makkai ata and 1 oz. of dal.

THE SUGGESTED SCALES.

General diet.

Burma or country rice	12 ozs.
Wheat ata	10 „
or	
Makkai ata	12 „
Various dal available	5 „
Vegetables	6 „

Diet on two days a week.

Burma or country rice	12 ozs.
Wheat ata	8 „
or	
Makkai ata	10 „
Various dal available	4 „
Fish	5 „
Vegetables	6 „

The general diet offers in round numbers :—

Protein	93 grms.
Carbohydrate	550 „
Fat	32 „

which is superior in practically all its constituents to the dietary of Lower Bengal, and, being partly made up by wheat, is very much more assimilable. The important part, however, is that the protein absorption obtainable from this diet is a good deal higher than that from the full Behari diet at present in force ; so that less residue remains to provide for micro-organismal growth. The carbohydrate element is still too high for natives of a hot climate from whom hard labour is not demanded ; nevertheless, it is decidedly superior in this respect to the ordinary jail standard. If the suggested supply of fish meets with approval it will cause a reduction of the carbohydrate to more nearly a proper amount and, at the same time, increase the percentage of assimilable protein very considerably.

We need hardly say that, if it is decided to add a little animal protein to the diet, and fish is not available, goat's flesh will do equally well. The expense of this, however, we are afraid will be considerable, if not entirely prohibitive.

The fish diet two days a week offers in round numbers :—

Protein	100 grms.
Carbohydrate	480 „
Fat	30 „

a very superior diet, as a high percentage of its constituents is assimilable.

Nothing now remains with regard to the work done on the nutritive value of the dietaries of Lower Bengal and Behar jails, but to discuss a few of the questions that have cropped up during the enquiry—these we have tabulated under Section (5)—and to give our general conclusions.

We shall now take up the relative value of the different forms of food-stuff in use.

SECTION 5.

(i) Relative value of Burma and Country rice.

This subject will be found referred to in the work recorded on prisoners in the Presidency jail, Calcutta, and Buxar jail.

In the Presidency jail, Calcutta, where the prisoners have been getting Burma rice only from the time of their incarceration, the protein absorption from the different diets containing Burma rice was on the average higher than that observed in Puri jail, where locally grown rice was always in use.

Further, on placing two batches of prisoners in the Presidency jail on absolutely similar diets, but replacing the Burma by country rice, there was a distinct fall in the actual amount of protein absorbed from the diet. Thus a batch of 10 healthy Bengali prisoners on a diet of Burma rice, mixed massur and arhar dal and vegetables, gave an average nitrogenous metabolism of 7·60 grms., while the same prisoners under exactly the same conditions, save that country rice replaced the Burma rice, showed a fall in nitrogenous metabolism to just 7·00 grms.

This would appear to mean that the protein of Burma rice is more easily absorbed than that of country rice—at least in those who are accustomed to its use.

On the other hand, we have given evidence that in Behar jails the country product is accompanied by the better protein absorption—see comparative Charts IX and XIII. There were other factors, however, to be taken into consideration, so that the difference in the rice may not be the whole explanation of the better absorption from diets containing country rice.

We are inclined to believe that to those accustomed to it, the Burma variety is distinctly superior to the country rice as placed on the market. We think that a good deal of the inferiority of country rice is due to its very dirty condition, and to bad cleaning. There is no doubt, however, that the prisoners prefer the home-grown product, and, as we have seen, this is an asset not altogether to be neglected.

That Burma rice, when properly treated, is just as likely to maintain the prisoners in health as is the Indian variety, is shown by the health returns of prisoners in the Presidency jail, Calcutta, where nothing but Burma rice has been used for the past three years. From our results as to its relative nutritive value we have no hesitation in recommending the more extensive use of Burma rice in Bengal and Behar jails.

(ii) The relative value of the different dals.

We have practically nothing to add to what will be found under the work recorded in Tables II, III and XIII. Given in what we have called the optimum

quantity, there appears to be very little difference in the amount of protein absorption from diets containing different dals, with the exception of gram dal. This contains a much lower percentage of protein than the other types, and its protein does not appear to be so easily absorbed. Any difference that exists in the protein absorption of the different dals is, in all probability, due to a difference in the relative difficulty of thoroughly cooking them.

The cooking of dals and of the different constituents of the dietaries is a most important question, and one we have been unable to touch; but there can be no doubt that the very deficient protein absorption from the jail dietaries is intimately connected with the way in which the food is prepared.

(iii) The relative values of wheat and makkai ata.

The relative values of these two food-stuffs have already been fully discussed. When 12 ozs. of makkai ata are given in place of 10 ozs. of wheat ata we found that it made an average difference of about one gramme of nitrogen in the amounts absorbed from the two diets with varying quantities of rice. This works out to over 10 per cent. of a decrease in the level of nitrogenous metabolism. When equal quantities of makkai and wheat ata are given in substitution for one another (Buxar jail) we saw that the level of protein metabolism was decreased 1·6 grms. on the average, the makkai ata being used with varying quantities of rice. On contrasting, however, the proportion of protein of makkai with that of wheat ata, in a diet containing 10 ozs. of each, we obtain a full explanation of the lower absorption from makkai ata: the protein of makkai ata is to that of wheat ata as 9·55 : 12·24, *i.e.*, as 1 : 1·2, and we found that under the same conditions the average absorption from a diet containing makkai was to that of a diet containing wheat as 8·03 : 9·69, *i.e.*, as 1 : 1·2 (see Charts III and V).

It follows from this that the protein of makkai ata is, under the same conditions, as well assimilated as that of wheat ata. This is an important result, as it is generally stated that makkai is much less easily absorbed than wheat; however, our investigations do not bear out that contention, but show, on the contrary, that practically the same percentage of the protein of the two food-stuffs is absorbed when they are given under the same conditions.

The fact that the ratio of the percentages of the protein of makkai ata and wheat ata tallies with the ratio of absorption of those proteins affords a valuable check on the accuracy of the figures on which the charts are founded.

We present on Chart XIV composite curves obtained by averaging the results of the investigation carried out in Buxar and Bhagulpur jails on diets of makkai

and wheat ata, when the rice was in varying quantities in the several diets. This chart shows very clearly the relative value of makkai and wheat ata, so far as protein absorption is concerned, makkai being given in quantities of 11 ozs. and wheat ata in quantities of 10 ozs. Both curves present the same features in almost every detail, showing the gradual rise as the rice is increased from 8 to 10 ozs., the sudden increase in protein absorption from 10 to 12 ozs., and the typical fall after the amount of rice has been increased beyond the optimum. The point on the chart for 14 ozs. is calculated; as in Bhagulpur jail this figure was irregular from a fall in the amount of makkai ata consumed.

General summary of results obtained.

1. We have shown the worth of the dietaries of Bengal in grms. of proximate principles, and pointed out that their real nutritive value is very different from their apparent worth. The chemical values of the diets in round numbers are, in protein, for Lower Bengal diets 93 grms. and for Behar 106 grms.; the real nutritive value for Lower Bengal is 49 grms. and for Behar 60 grms. In other words a little over 50 per cent. of the protein is absorbed from the dietaries when given in full quantities.

2. We discussed the causes of this low absorption and have shown that one important factor in retarding the metabolism of protein from the full diet is bulkiness, affecting both types of diet.

We brought forward much evidence to show that a mere decrease in the bulk of the diet was sufficient to permit of a greater relative and absolute absorption of protein; and, working with varying quantities of the different food-stuffs, we gradually worked out the amount of each food-stuff that should be given in a diet, in order that the absorption from that diet may be at a maximum—this we called the optimum amount.

For diets of the Lower Bengal type the optimum quantity of rice we found to be 18 ozs. and of dal 5 ozs. (about) per man daily.

In Behari diets the optimum amount of rice is 12 ozs.
„ „ „ „ wheat ata 10 ozs.
„ „ „ „ makkai ata 12 ozs.
„ „ „ „ dal 6 ozs.

We showed that the absorption from the diets, in which the food-stuffs were combined in the proper quantities, was very much superior to that of the present scales of dietaries; also that the percentage absorption was very much higher—a great gain, as a much lessened amount of nitrogen remains to undergo intestinal

putrefaction. Further, we showed that, by giving the several food-stuffs in the quantities which we suggest, the acknowledged excessive carbohydrates of the diets are brought down to more nearly physiological amounts, and that the intestinal juices are given a fair opportunity of discharging their duties, so that intestinal fermentation will be checked and a better absorption of carbohydrates will be obtained. If we had any means of investigating the metabolism of carbohydrates we should, in all probability, obtain a curve very similar to that given in Chart II which shows the actual absorption of protein from diets containing different quantities of rice. It is quite fair to assume that the conditions present in the diets that entail so defective an absorption of protein will also tend to prevent the full value of their carbohydrate elements being made use of. These conditions will remain in force until the food has passed those parts of the intestinal canal where absorption of both protein and carbohydrates is possible; but, having arrived at the large bowel, the carbohydrates are rapidly broken down by fermentative processes, and their potential energy is dissipated, so that estimation of the carbohydrates passed out in the fæces is of no value as a criterion of the percentage of that element wasted and lost to the economy. This is not the case with the protein element, for the nitrogen left over from absorption must pass out in the fæces in some nitrogenous form, either inorganic or organic, as, for instance, in the form of organised micro-organisms, for whose growth it forms the essential pabulum. The estimation of the nitrogen of the fæces, therefore, gives a true indication of the amount of residual waste from the protein of the diet. We have confirmed our results by this method particularly in the cases of Presidency jail, Puri jail, and Midnapore jail.

We have given graphic records of the effects on protein metabolism obtained from diets providing varying quantities of the different elements when all but one constituent of the diet remained constant. In this way, we have been able to plot out the curves of the absorption of protein for different types of diets. In all these investigations we worked with the diet as a unit, and did not accept the assumption that there would always be the same actual absorption from the "basal" or our "constant" part of the diet, with varying quantities of the food-stuff under investigation. In fact, we have shown that the above-mentioned assumption, while practically true for diets of the European type where an average of 90 per cent. of the protein is absorbed, does not hold good for dietaries of the Bengal type. It is not possible to work out an absorptive protein co-efficient for the several food-stuffs, and find that this percentage of its protein will be absorbed under varying conditions. We find, on the contrary, that the absorptive co-efficient varies more or less inversely with the bulk of the diet, and with the amount of vegetable protein present in the diet; and it is only after a great reduction in bulk, and in diets whose protein metabolism approaches the lower

physiological limits that the addition of more of a food-stuff will show an increased protein absorption corresponding to a co-efficient of absorption similar to that obtained in European types of diets.

A great deal of work has been done on the effects of adding wheat ata or an animal protein to the Lower Bengal dietaries and an animal protein to the Behar diets.

These effects we have fully discussed in the summaries of the sections dealing with them and we have nothing more to add on this subject.

3. We have stated that, while the addition of an animal protein is not by any means essential, at the same time there is little doubt that, if it were economically possible thus to permit of a reduction of the amount of dal in both Lower Bengal and Behar dietaries, the general health of the jails would improve. From investigations on the microscopic compositions of the fæces it would appear that the dal granule is the most difficult of all to break down, and that the slightest lowering of the general health is usually accompanied by the passage of undigested dal. This has clearly been shown by Lane* in the microscopic examination of the fæces of prisoners for intestinal parasites; the presence of more or less harmless parasites being sufficient to cause the passage of large quantities of unchanged dal granules. It is easy to replace part of the dal in Bengal jails by wheat ata without increasing the cost—and this we have recommended. But in Behar jails the amount of wheat or makkai ata is quite sufficient and cannot be increased with good effect. The only way, therefore, of being able to reduce the dal is to give some form of animal protein, and we have suggested fish. It would only be necessary to do this in the large central jails where long-term prisoners are confined, and in the two central jails that we examined fish should be easily procurable at little over the cost of prison labour, if proper arrangements were made.

These changes in the feeding of prisoners would require to be carefully considered from the standpoint of cost before being generally introduced. However with regard to the other suggestions put forward there need be no hesitation. The quantities of rice in the Bengal and Behar diets must be reduced; the former by 8 ozs. and the latter by 4 ozs. per man daily.

We are very strongly of the opinion that 6 ozs. of dal is far too great a quantity and should like to see it reduced to 4 ozs. in both types of diet; this can be done easily in Lower Bengal by replacing it by a corresponding quantity of wheat ata, or wheat ata and fish in those jails where it is found more economical to give fish on two days per week or oftener. In Behar jails, particularly in the large central jails, we hope that it will be possible to give fish twice a week in order that the excessive amount of dal necessary may be further reduced.

* Major Clayton Lane, I.M.S.: Intestinal Parasites, I. M. G., 1909.

If this be not feasible we strongly recommend that the 6 ozs. of dal be reduced to 5 ozs. per man daily.

The dietaries we recommended would, therefore, be :—

I.—Lower Bengal Jails.

Rice, Burma or country	18 ozs.
Dals, various kinds available	4 „
Wheat ata	4 „
or	
Fish in place of wheat ata twice a week	4 „
Vegetables	6 „

II.—Behar Jails.

		On two days a week.
Rice, Burma or country	12 ozs.	12 ozs.
Wheat ata	10 „	8 „
or		
Makkaiata	12 „	10 „
Dals, various kinds available	5 „	4 „
Vegetables	6 „	6 „
Fish or goat's flesh	..	5 „

[*Re* salt—see later.]

The usual condiments, etc., as at present in use.

4. We have discussed these diets from the standpoint of the interests of the prisoners, and have brought forward evidence to show that the suggested changes are entirely to their advantage, and to the benefit of their general health. This we consider is the all-important consideration, as it would be no saving to the State, to look at the problem from the economical point of view alone, if a reduction in the cost of dieting were made, and it entailed greater sickness or any lowering of the general health. Fortunately, in this matter the interests of the prisoners and of the public, who have to pay for the prisons, are not at variance, for we are able to suggest much superior types of diet which will cost the State less than at present.

The general effect of our suggestions would be to decrease the quantity of rice all over Bengal by 6 ozs. per man daily. The other changes from the point of view of cost may be neglected, as the addition of wheat ata would counterbalance the decrease in dal in Lower Bengal; however, if fish were procured by prison labour there would be a distinct gain in both Bengal and Behar. On the whole there would be a saving of one-fourth the cost of all the rice consumed.

From data supplied by jail officers we find that rice costs on an average one anna per man daily, so that there should be a saving of 3 pies on each prisoner per day. Calculating on a basis of 16,000 prisoners in Bengal, from rice alone this would work out at a saving of over three-quarters of a lac of rupees yearly. Besides this, if our suggested means of obtaining fish were possible, there would very nearly be a similar saving on dal, wheat and makkai ata.

The details would require to be worked out with regard to local conditions, but we have no doubt that in most of the central jails, and in many of the smaller, fish could be cheaply obtained. On the whole there would certainly be a lac of rupees saved every year—and probably much more, if the diets which we have shown to be much superior in every detail to the present standards were introduced.

5. With regard to the cooking of these vegetable food-stuffs we have not been able to make any observations; but from the evidence afforded by other observers we would recommend that the dal be ground to meal before being cooked. We hope to be able to make some investigations on this important subject later. As already mentioned, lentils given after soaking and boiling show over 40 per cent. of the protein unabsorbed; whereas when ground to lentii meal only from 8 to 10 per cent. of the lentil protein passes out in the fæces.

CHAPTER III.

Report on six months' use of special diets in Puri Jail.

By the end of 1908 we had obtained undoubted evidence of the beneficial effect of a reduction of the bulk of the ordinary jail diet on the level of protein metabolism; it was therefore necessary to determine whether such a reduction would be accompanied by a maintenance in the standard of the prisoners' health and their physical condition. With this object in view it was decided, in consultation with the Officiating Sanitary Commissioner with the Government of India—Lieutenant-Colonel W. J. Bamber, I.M.S.—and the Inspector-General of Prisons, Bengal—Lieutenant-Colonel W. J. Buchanan, I.M.S.—to place all the prisoners in Puri jail on diets in which the bulk had been considerably decreased. This arrangement was carried out over a period extending from the beginning of January to the end of July 1909.

This experiment of some six months' duration is not really of much value in determining the effects of the lessened diet on prisoners over long periods, as Puri being a District jail few of the prisoners remained for more than from one to two months. It shows, however, the effects of the diet on the new admissions and on those prisoners under confinement when the experiment was begun: by a comparison of the results thus obtained with those of the same period in previous years, we are able to form a fair idea of the effect of the reduction of the bulk of the ordinary jail diet.

The prisoners were divided into two classes of a nearly equal number of prisoners in each. One class was given a diet composed of—

Class A.

Rice . . .	18 ozs.	Fish . .	4 ozs.
Dals . . .	4 „	Vegetables . .	6 „

The other a diet composed of—

Class B.

Rice . . .	18 ozs.	Wheat ata . .	4 ozs.
Dals . . .	4 „	Vegetables . .	6 „

A batch of five men were selected from each of these two classes at the beginning, in the middle and at the end of the experiment: these batches were

placed on accurately weighed diets given as above for classes A and B, and the amount of nitrogen undergoing metabolism estimated. The figures obtained will show that practical identical amounts of nitrogen were absorbed from the diet of class A during the different periods, and from that of class B during the different periods; thus again proving that the level of nitrogenous metabolism is dependent on the quantity of absorbable protein offered in a diet, and not affected, at least to any great extent, by the time during which an individual has been on that diet.

The work done in estimating the degree of nitrogenous metabolism present during these periods also shows how very marked an influence a diminution in the quantity of rice and *dal* and a substitution for them of a certain amount of wheat ata or fish, has in raising the relative and actual percentage of protein absorption.

We shall first give an account of this work and then analyse the figures collected to show the effects of the diets.

Puri Jail.

Investigations to establish the level of protein metabolism at the beginning and at the end of the six months' experiment: the two classes A and B of prisoners having been kept on their respective diets continuously during the whole period.

TABLE XXII*a*.

Class A.

Diet.

Five Ooriya prisoners observed over five consecutive days.

1st Period, January 1909.

Country rice	20 ozs.
Mixed dal	4 ,,
Fish	4 ,,
Vegetables	6 ,,

Total N. of intake = 325·7 grms.

Total nitrogenous metabolism = 240·01 grms.
=73·69 per cent. of the total N. of the diet.
=9·60 grms. N. per man daily.

2nd Period, July 1909.

Country rice	18 ozs.
Mixed dals	4 ,,
Fish	4 ,,
Vegetables	6 ,,

Total N. of intake = 313·36 grms.

Total nitrogenous metabolism = 238·13 grms.
= 75·99 per cent. of the total N. of the diet.
= 9·52 grms. of N. per man daily.

Class B.

Diet.

1st Period, January 1909.	Country rice	20 ozs.
	Mixed dals	4 "
	Wheat ata	4 "
	Vegetables	6 "
Total N. of intake = 296·30 grms.	Total nitrogenous metabolism = 204·70 grms.	
	= 69·00 p. c. of the total N. of the diet.	
	= 8·19 grms. of N. per man daily.	
2nd Period, July 1909.	Country rice	18 ozs.
	Mixed dals	4 "
	Wheat ata	4 "
	Vegetables	6 "
Total N. of intake = 296·30 grms.	Total nitrogenous metabolism = 203·78 grms.	
	= 68·77 per cent. of total N. of diet.	
	= 8·15 grms. of N. per man daily.	

Collating these results we find—

(i) With the fish diet an average metabolism of nitrogen of about 9·5 grammes per man daily;

(ii) With the ata diet an average metabolism of nitrogen of about 8·1 grammes per man daily;

which is to be contrasted with the degree of nitrogenous metabolism attained on the ordinary jail diet, and which we have seen to be, for Puri prisoners, 7·4 grms. per man daily. Further, the percentage absorption of protein is greatly increased by the change, *viz.*, from 50 per cent. to quite 74 per cent. with the fish diet and to 69 per cent. with the wheat ata diet.

We therefore see that the level of nitrogen exchange can be greatly raised and the percentage of protein absorption immensely increased by a very simple change in the ordinary jail diet, and that, by the change that we have suggested a good deal of the excessive carbohydrate of the jail diet will be got rid of at the same time.

We shall now examine the evidence we have been able to collect as to the effect of these dietary changes on the health and general well-being of the prisoners under observation.

The first effect of the reduction of the bulk of the diet was to cause a certain amount of grumbling on the part of the prisoners, particularly those in class A, on the fish diet. This went on for a few days but in a very short time the stomach became accustomed to the diminished bulk and the feeling of emptiness complained of disappeared. This is all the more remarkable in Ooriyas as they are the only people we have come across who are able to consume consistently the full jail ration. Those in class B, on the wheat ata diet, never complained much, probably on the whole less than they do on the full jail diet. The period of the experiment was too short to draw any conclu-

sions from the incidence of sickness. There were very few cases of sickness serious enough to call for admission into hospital amongst the prisoners in either class. Thus in the return for 1908 with an average daily strength of 174·59 there were 92 admissions into hospital, while during the six months the prisoners were on these modified diets the total admission into hospital were on a very much lower scale. While this is statisfactory, so far as it goes, no conclusions can be drawn from it, as the sickness rates vary very much from year to year quite independent of the diet.

The only means of contrasting the results of the change that gives any real measure of comparison is its effects on the body-weight, and even this is apt to be fallacious. If the special diets had only been given to prisoners newly admitted and their effects on the body-weight noted, a comparison with the results of former years would have been of value; but we had to place the total prisoners of the jail on the diets and the number of new admissions was too small to afford conclusive evidence.

It is well-known that prisoners on first admission increase in body-weight to a very marked extent.

Thus the percentage of those who increased in weight during the year 1907 was 58 and in 1908 was 53·8 in the jails of Bengal. In 1908, 62 per cent. of the prisoners in Puri jail increased in body-weight.

We have by a comparison with these figures a means of measuring the results obtained from the change of diet.

Class A.

Fish Diet.

(i). Total prisoners on this diet for a period up to one month=165.

Of these 94 increased in weight by an average of 2·6 lbs.
„ „ 55 decreased „ „ „ „ 1·9 lbs.
„ „ 16 remained stationary.
=56 per cent. gained in body-weight.

(ii). Total prisoners on this diet for a period up to two months=104.

Of these 64 increased in weight by an average of 3·6 lbs.
„ „ 19 decreased „ „ „ „ 2·1 lbs.
„ „ 21 remained stationary.
=61 per cent. gained in body-weight.

(iii). Total prisoners on this diet for a period exceeding two months=31.

Of these 20 increased in weight by an average of 4·3 lbs.
„ „ 6 decreased „ „ „ „ „ „ 2·0 lbs.
„ „ 5 remained stationary.
=64 per cent. gained in body-weight.

That is, for the usual period during which prisoners are retained in a small district jail, like Puri jail, the percentage of those showing an increase in body-

weight is quite up to the average even when the total bulk of the jail diet is considerably diminished by a decrease of 8 ozs. in the amount of rice, 2 ozs. in the amount of dal—but when 4 ozs. of fish is added to the daily ration. This is strong evidence that the new diet is sufficient and meets all the physiological requirements of the body. We know that the level of nitrogenous exchanges is very greatly raised, the excessive carbohydrate element largely curtailed and the percentage of nitrogenous residue in the bowel much decreased by the substitution of a diet of this type for that laid down in the Jail Code; the whole tendency of the recent researches on metabolism is to show that these are the ends to be aimed at in the framing of diet scales which are based on proper physiological and rational principles.

Class B.

Wheat Ata Diet.

(i). Total prisoners on this diet for a period up to one month=240.

Of these 138 increased in weight by an average of 2·6 lbs.
,, ,, 55 decreased ,, ,, ,, ,, ,, ,, 1·9 lbs.
,, ,, 47 remained stationary.
=57 per cent. gained in body-weight.

(ii). Total prisoners on this diet for a period up to two months=99.

Of these 60 increased in weight by an average of 4·2 lbs.
,, ,, 22 decreased ,, ,, ,, ,, ,, ,, 2·0 lbs.
,, ,, 17 remained stationary.
=60 per cent. gained in body-weight.

(iii). Total prisoners on this diet for a period exceeding two months=25.

Of these 16 increased in body-weight by an average of 4·8 lbs.
,, ,, 5 decreased ,, ,, ,, ,, ,, ,, ,, 2·6 lbs.
,, ,, 4 remained stationary.
=64 per cent. gained in body-weight.

These results show that with a diet in which 4 ozs. of wheat ata replaces 8 ozs. of rice and 2 ozs. of dal of the ordinary jail diet, the percentage of prisoners who gain in body-weight is actually higher than is found to be the case on the jail diet.

Summary.—We may conclude from the evidence obtained from the Puri experiment that a diminution in the bulk of the present type of diet is urgently called for, and that by the substitution of a more assimilable form of protein in the form of fish or wheat ata for the excess of rice and dal, the general well-being and physical condition of the prisoners will be increased and placed on a higher level. The results also show that a change in the dietary, such as we have suggested, can be quite simply and easily carried out, and that, in a very short time, the early feeling of emptiness complained of passes away, the dilatation of the stomach so commonly met with in a rice-eating people becoming distinctly diminished.

CHAPTER IV.

The effect of the large quantity of salt given in Bengal Jails dietaries.

The quantity of salt given in the diet scales of Bengal jails is $\frac{14}{16}$th of an ounce which, when added to the salt contained in the food materials, brings the total up to well over an ounce or about 30 grms. of salt in the daily diet. It will be readily admitted that this is an excessive quantity and much beyond the physiological needs of the body.

Von Noorden states that probably the presence of as little as 3 or 4 grammes of salt in the daily diet is a sufficient protection against the loss of chlorine; and, so long as the chlorine supply does not fall below this, the decrease in the amount excreted in the urine will correspond to the diminished intake by the mouth. In recent years, due mainly to the researches of Widal, the question of salt in the diet has become a very important one, more particularly in connection with the causation of œdema from kidney disease, disturbances of the circulation, and even cirrhosis of the liver. It is generally admitted that by controlling the proportion of sodium chloride in the diet, the œdema of Bright's disease can be made to appear and disappear—a dechlorinated diet causing the œdema to disappear in a comparatively short period. At the recent German Medical Congress, on the discussion of Widal's paper it was conceded by all that the symptoms of anasarca are due to retention of chlorides in the tissues. Further, Dr. Magnus-Levy pointed out that, although the anasarca caused by cardiac disease and cirrhosis of the liver is of a mechanical nature, and not due to any impermeability of the kidneys to chlorides, he found that in these conditions also a dechlorinated diet has the effect of reducing the dropsy.

Mendel in a most instructive paper on "Salt-poor Diet as a Systematic method of treatment" published in the *Münchener medizinische Wochenschrift,* March 1909, discusses this subject in the light of recent experimental researches. He shows that even normal amounts of salt in the diet increase the fluid in the body from 1·5 to 3 litres, and that an excessive intake of salt may entail retention of salt and water even in healthy individuals with sound kidneys. The healthy organism tolerates this excessive amount of fluid without much sign of disturbance, but there is transudation and exudation whenever the vessels are damaged from any cause. The effects of hydræmic plethora, from salt accumulating with its accompanying water, is shown to be peculiarly striking in various skin and serous affections, especially in inflammations accompanied by exudations of serum through

the altered vessels. He finds that retention of salt and water not only alters the clinical picture of inflammation, but has a more or less injurious influence on its course. If the serous membranes are involved in the inflammation there is greatly increased effusion.

In inflammation generally the effusion is reabsorbed the more rapidly the less the salt taken in the food. The reduced proportion of salt leads to a powerful osmotic current from the tissues out into the blood and increases the diuresis, which further reduces the pressure in the interstices of the tissues, and this in turn favours reabsorption of the morbid effusion. Mendel describes striking cases to show how the course of a burn can thus be modified, also eczema, epididymitis, joint affections, venous thrombosis and arterio-sclerosis.

The whole bearing of the results of recent research on the salt question is to show that, when given in quantities above the physiological limits, salt is retained in the tissues; and, as it cannot be retained as crystals of sodium chloride, but only in a more or less isotonic solution, water to form that solution must also be retained in proportion to the amount of salt stored up in the body. The result is a more watery condition of the tissues of the body and, therefore, an increase in body-weight. Marey and Widal's experiments have clearly demonstrated these results in healthy individuals whose kidneys were quite permeable to chlorides. Now, so long as the tissues are healthy and uninjured no sign of this water-logged condition appears beyond the increase in body-weight; but, if for any reason injury is received, no matter what form of injury it may be—the water-logged tissues react to a much greater degree than would normal healthy tissues. If, at the same time, the kidneys are diseased the hydræmic plethora results in œdema, but long before any visible signs of œdema appear careful daily weighing will reveal a steady gain in body-weight. Much work has now been recorded showing the marked antiphlogistic and absorbent action of a salt-poor diet, and the favourable influence exerted on acute inflammatory processes by limiting the salt intake to as great an extent as possible.

We refer to these researches to show that the quantity of salt given in the daily food is not a matter of little importance but, on the contrary, that it may influence in a very unfavourable manner the ordinary ailments or diseases prevalent amongst the prisoners of Bengal jails. This is a side of the question we have had no opportunity of studying, but there is little doubt that careful observation would confirm the claims of Widal, Marey and Mendel and extend the list of morbid conditions in which limitation of the salt intake forms a most useful adjunct to the ordinary methods of treatment.

We shall now deal with our investigations on the effects of the large salt intake sanctioned for the prisoners of the jails of Bengal.

It may be accepted with regard to salt metabolism that, like protein, its level is determined by supply—with this difference that, whereas protein may be very defectively absorbed, salt is under ordinary circumstances almost completely absorbed by the intestinal tract. There is a widespread belief that, in consequence of man's habit of consuming an extravagant amount of salt, a certain superfluity of it remains in the body. How large this excess from salt consumed may be is best seen from investigations in which its disappearance can be traced, as in fasting or in abstinence from sodium chloride alone.[1]

From observations on professional fasters who, previous to the period of fasting, had contented themselves with moderate quantities of common salt—about 10 grammes daily—the amount of salt given off by the body during the fast was estimated at 17 or 18 grammes. It has not been absolutely determined whether larger amounts are amassed in the body in cases where salt is taken in larger quantities—20 to 25 grammes. It is very probable, however, that such is the case. The effect of placing an animal on large quantities of sodium chloride has been shown to cause an increase of body-weight, which can only be explained by a retention of water in sufficient quantity to dilute the salt retained to a solution isotonic with the fluids of the body. The opposite holds true to an even greater extent; for, while salt equilibrium may become established so quickly on increasing the amount of salt that no, or only a slight, increase in body-weight results, the effect of decreasing or stopping salt altogether is to cause at once a loss in body-weight which is greater than can be accounted for by loss of flesh, and is due to water being lost together with the sodium chloride. That is, when the administration of salt is largely decreased or stopped the excretion of chlorides in the urine is greater than the salt intake so that the body becomes poorer in salt, and less water is required to maintain the isotonicity of its solution: the body-weight therefore falls.

We shall consider the effects of the large sodium chloride intake of the prisoners on body-weight, diuresis and number of red blood corpuscles. We shall also give some observations on the effect of the large salt intake on its elimination by the fæces and skin.

Investigations to determine the effects of large quantities of salt on:—

(*i*) The amount of chlorides passed in the urine.
(*ii*) ,, ,, ,, ,, ,, ,, ,, fæces.
(*iii*) ,, ,, ,, ,, ,, ,, ,, sweat.
(*iv*) The body-weight.
(*v*) The total amount of urine passed.
(*vi*) The number of red blood corpuscles.

[1] Von Noorden, The Physiology of metabolism.

Puri Jail.

1. The effects of a sudden decrease in the amount of salt in the diet. The unit worked with was five prisoners; the urine and fæces were collected and pooled.

TABLE XXIII.

Five Ooriya prisoners observed for fifteen consecutive days.

Batch A.	Total quantity of urine.	Chlorides of urine.	Chlorides of fæces.	Weight of pris.	R.B.C. average count.	Salt intake.	Chlorides of sweat = difference of total intake and output in urine and fæces.
	c.c.	grms.	grms.	lbs.		grms.	Average per man daily.
Five prisoners, Ooriyas.	8,500	85·00	2·80	98·6	Average of 13 counts on two prisoners = 4,790,000	99·71	= 2·37 grms.
	9,940	86·97	2·60	99·0		99·71	
	10,000	71·00	2·65	97·8		99·71	
	10,150	96·34	1·10	96·8		99·71	
	7,800	80·38	1·83	97·5		99·71	
	9,080	77·18	1·96	96·7		99·71	
	9,100	86·40	3·48	97·1		99·71	
	9,930	99·60	2·35	96·3		99·71	
	8,700	87·00	1·92	96·4		99·71	
	8,820	85·55	2·29	96·9		99·71	
	8,490	72·38	2·20	96·4		32·80	Transition day.
Do. ..	7,420	31·16	2·20	95·8	4,734,000	32·80	= ·19 grms.
	5,790	35·89	2·44	95·8		32·80	
	7,350	30·12	1·89	95·4		32·80	
	7,460	29·16	2·12	95·1		32·80	

What do we find from this investigation?

With practically 20 grms. of salt per man daily:—

(i) 86 per cent. is absorbed and passed out in the urine.

(ii) 2·4 per cent. is unabsorbed and passes out in the fæces.

(iii) 11·6 per cent. is absorbed and passed out in the sweat.

(iv) average body-weight = 97·31 lbs.

(v) average quantity of urine passed = 1,840 c. c. per man daily.

(vi) number of corpuscles = 4,790,000 (average).

With 6·5 grms. of salt per man daily:—

(i) 93·4 per cent. is absorbed and passed out in the urine.

(ii) 6·6 per cent. is unabsorbed and passes out in fæces.

(iii) 2·8 per cent. is derived from the excess of salt stored in the body.

(iv) average body-weight = 95·4 lbs.

(v) average quantity of urine passed = 1,401 c.c. per man daily.

(vi) number of corpuscles = 4,734,000.

That is, with the same batch of men on the same diet throughout the whole experiment, the effects of reducing the quantity of salt from 20 to 6·5 grms. per man daily were:—

(i) to cause a distinct fall in body-weight from an average of 97·3 to 95·4 lbs.,

(ii) to decrease the average amount of urine passed from 1,840 c.c. to 1,401 c.c. per man daily.

Other points brought out in this investigation are:—

(iii) The very high percentage of salt absorbed even when large amounts are given in the diet: thus, in the 20 grammes period, no less than over 97 per cent. of the total salt given was absorbed by the bowel.

(iv) The very constant quantities eliminated by the fæces so long as there is no actual diarrhœa: with an intake of 20 grms. 0·46 grm. NaCl

was passed in the fæces per man daily; with 6·5 grms. 0·43 grm. passed in the fæces per man daily.

(*v*) It will be noticed that a larger quantity of NaCl was eliminated in the urine and fæces than was present in the intake during the period that the prisoners were getting 6·5 grms. daily. The excess derived from the salt stored in the body, over the four days we have taken into consideration, is very small—only 3·89 grms. for the batch of five men, or 0·78 grm. per man. However, if we take the "transition day"—the period before salt equilibrium is established—into consideration, the excess works out to 15·25 grms. per man over the five days. This excess is of course not entirely due to salt stored up in the body, but is simply the remains of the salt from the previous day's supply which had not yet been eliminated. We have not taken the "transition day" into our reckoning.

(*vi*) There is no doubt that a considerable quantity of salt is eliminated by the perspiration in hot climates like India. In our first period this formed 11·6 per cent. of the total, or 2·37 grms. per man daily; in the second period it was not possible to calculate the amount eliminated by the sweat as the total intake of salt was not sufficient to maintain salt equilibrium. It is highly probable that the quantity of salt got rid of by the skin depends on the total amount of the salt intake. When this is considerable thirst is raised, and the ingestion of large quantities of water increases the action of the skin; under the opposite conditions the skin does not act so freely, and therefore smaller quantities of salt will be excreted by it.

(*vii*) The enumeration of the red blood corpuscles shows a decrease with the decrease in the salt intake. This decrease we did not expect, and it is at variance with our results obtained from experiment on animals in the laboratory, where the conditions were more under control than in the jails. Further, the limit of error in blood counting is high—quite up to 5 per cent., and the count involves a great deal of labour when batches of five men are made use of. The method we prefer, and the one made use of in the laboratory is by means of the high-speed electric hæmatocrite, to determine the percentage volume of the corpuscles under different conditions of salt intake. This we found impossible to carry out in the jails visited. Further work will be necessary on the question whether the intake of salt causes an increase or decrease in the number of the blood corpuscle before any definite statement can be made.

2. The effects of a gradual decrease in the amount of salt in the diet.

Five Ooriya prisoners observed during fifteen consecutive days.

Batch B.	Total quantity of urine.	Chlorides of urine.	Chlorides of fæces.	Weight of pris.	R.B.C. average count.	Salt intake.	Chlorides of sweat.
	c.c.	grms.	grms.	lbs.		grms.	grms. Average per man daily.
Five prisoners, Ooriayas.	8,970	89·00	2·36	98·8	4,550,000	99·71	2·51
	10,100	91·00	3·65	98·8		99·71	
	9,020	80·72	2·75	98·8		99·71	
	8,180	76·54	1·60	98·7		99·71	
Do.	8,130	62·80	2·31	97·6	4,570,000	73·8	=1·09
	9,190	62·49	3·80	97·9		73·8	
	8,880	62·12	3·02	98·2		73·8	
	8,550	72·58	3·26	98·1		73·8	
Do.	8,390	44·46	3·16	97·9	4,520,000	49·2	=0·41 grm.
	6,610	46·27	3·14	97·8		49·2	
	8,000	43·16	2·02	97·7		49·2	
	7,500	43·20	2·16	97·5		49·2	

What do we learn from this investigation ?

With practically 20 grms. of salt daily per man :—

(*i*) 84·5 per cent. is absorbed and passed out in the urine.
(*ii*) 2·5 per cent. is unabsorbed and passed out in the fæces.
(*iii*) 13·0 per cent. is absorbed and eliminated in the sweat.
(*iv*) average body-weight = 98·8 lbs.
(*v*) average quantity of urine passed = 1,816 c.c.
(*vi*) average number of r.b.c. = 4,550,000.

With 14·76 grms. of salt per man daily :—

(*i*) 88·1 per cent. of the salt is absorbed and passed out in urine.
(*ii*) 4·2 per cent. is unabsorbed and passed out in the fæces.
(*iii*) 7·7 per cent. is absorbed and eliminated in the sweat.
(*iv*) average body-weight=97·9 lbs.
(*v*) average quantity of urine passed=1,740 c.c.
(*vi*) average number of r.b.c.=4,570,000.

With practically 10 grms. of salt per man daily :—

(*i*) 90 per cent. of the salt is absorbed and passed out in the urine.

(*ii*) 5·3 per cent. is unabsorbed and passed out in the fæces.

(*iii*) 4·7 per cent. is absorbed and passed out in the sweat.

(*iv*) average body-weight=97·7 lbs.

(*v*) average quantity of urine passed=1,225 c.c.

(*vi*) average number of r.b.c.=4,520,000.

These results are very similar in type to those recorded in (1) of this table, but are more gradually obtained. There occurred a gradual fall in body-weight and a decrease in the amount of urine secreted after each successive decrease in the quantity of salt given in the dietaries.

The same constant quantities of salt are eliminated by the bowel: in the three sets of observations these were 0·51, 0·62 and 0·52 grm. per man daily, from which it would appear probable that practically all the added salt of the diet is absorbed, and that the salt passed in the fæces is derived from that contained in the constituents of the diet, *i.e.*, from the undigested food materials.

These observations also bring out the gradual drop in the amount of salt eliminated by the skin as the quantity ingested is decreased. Thus with the diminishing quantities of salt our table shows 2·51, 1·09 and 0·41 grms. per man daily as the amount unaccounted for in the urine and fæces. This result is very similar to that shown in (1) of this table.

3. The effects of decreasing and increasing the amount of salt in the diet.

Five Ooriya prisoners observed during fifteen days.

Batch C.	Total quantity of urine.	Chlorides of urine.	Chlorides of fæces.	Weight of pris.	R.B.C. average count.	Salt intake.	Chlorides of sweat.
	c.c.	grms.	grms.	lbs.		grms.	grms. Average per man daily.
Five prisoners, Ooriyas.	9,150	85·52	3·56	98·6	3,420,000	99·71	=2·88
	8,220	101·19	1·33	98·6		99·71	
	8,340	63·55	1·23	98·8		99·71	
	8,920	83·36	1·34	98·7		99·71	
Do	6,890	45·09	1·68	98·1	3,450,000	57·4	0·86 grm.
	7,900	58·46	2·62	98·3		57·4	
	7,430	45·32	2·40	98·4		57·4	
	6,540	54·28	2·58	98·4		57·4	
Do	7,000	59·50	2·96	98·6	3,533,000	65·6	1·04 grms.
	6,370	50·9€	1·55	98·6		65·6	
	6,500	61·00	2·36	98·6		65·6	
	6,000	55·00	2·86	98·7		65·6	
	6,800	62·40	3·34	98·8		65·6	

What do we learn from this investigation ?

With practically 20 grms. of salt per man daily :—

(*i*) 83·6 per cent. of the salt is absorbed and passed out in the urine.
(*ii*) 1·8 per cent. of the salt is unabsorbed and passed out in the fæces.
(*iii*) 14 per cent. of the salt is absorbed and passed out in the sweat.
(*iv*) average body-weight=98·7 lbs.
(*v*) average quantity of urine=1,731 c.c.
(*vi*) average number of corpuscles=3,420,000.

Practically with 11·5 grms. of salt per man daily :—

(*i*) 88·5 per cent. of the salt is absorbed and passed out in the urine.
(*ii*) 4·0 per cent. of the salt is unabsorbed and passed out in the fæces.
(*iii*) 7·5 per cent. of the salt is absorbed and passed out in the sweat.
(*iv*) average body-weight=98·3 lbs.
(*v*) average quantity of urine passed=1,438 c.c.
(*vi*) average number of r.b.c.=3,450,000.

Practically with 13 grms. of salt per man daily :—

(*i*) 88·0 per cent. of the salt is absorbed and passed out in the urine.
(*ii*) 4·2 per cent. of the salt is unabsorbed and passed out in the fæces.
(*iii*) 7·8 per cent. of the salt is absorbed and passed out in the sweat.
(*iv*) average body-weight=98·6lbs.
(*v*) average quantity of urine=1,307 c.c.
(*vi*) average number of r.b.c.=3,533,000.

These results confirm what we have already found in investigations (1) and (2) except for a deficiency in the quantity of urine with 13 grms. of salt in the diet. However, we have made hundreds of other experiments on this effect of salt, and the evidence is very strongly in favour of an increase of salt being followed by an increase in the quantity of urine passed.

We may sum up the conclusions arrived at from these observations by saying :—

(1) The evidence is strong that a large ingestion of salt in the diet entails an increase in the body-weight, an increase in the quantity of urine secreted, and a marked increase in the amount of salt eliminated by the skin.

(2) The quantity of chlorides passed in the fæces is very constant, and bears no relation to the total intake of salt in the food ; it, in all probability, varies with the percentage of the food-stuffs that passes out unabsorbed ; so that, in those experiments where the same foods in the same quantities were given throughout, the salt in the fæces is practically constant. It is a very small amount—only about 0·5 grm. per man daily.

(3) Practically complete absorption of the added salt takes place whether the amount is large or small.

(4) The results obtained from the enumeration of the r.b.c. are disappointing and colourless—the variations shown are within the limits of experimental error.

(5) The fact that as the quantity of salt ingested increases the skin has to be called more and more into action in order to assist in its elimination, points to large quantities of salt being unnecessary, and more than can be easily got rid of by the kidneys. The rational indication would therefore appear to be to give the amount of salt which the kidneys are best able to deal with, and which throws no great strain on them.

Our results show :—

With 20 grms. added to diet there is eliminated by the skin	2·58 grms. per man daily.
With 14·76 grms. added to diet there is eliminated by the skin	1·09 ,, ,, ,, ,,
With 13·00 grms. added to diet there is eliminated by the skin	1·04 ,, ,, ,, ,,
With 11·50 grms. added to diet there is eliminated by the skin	0·86 ,, ,, ,, ,,
With 10·00 grms. added to diet there is eliminated by the skin	0·41 ,, ,, ,, ,,
With 6·50 grms. added to diet the total excreted is greater than intake.	

So far as these observations go, therefore, we see that 6·5 grms. per man daily is too small a quantity, at least when the amount of salt is suddenly reduced from 20 to 6·5 grms. daily. The addition of 10 grms. of salt to the daily diet shows the lowest elimination by the skin and would therefore mean, if our deduction is correct, that the kidneys are easily able to deal with that amount without falling back to any great extent on the assistance ot the skin.

With regard to the optimum excretion of NaCl. by the skin we have exceedingly little information. Crammer[1] states that in severe muscular work with much perspiration it may amount to 1·6 to 2·2 grms. during the day. So far as we are aware there has been no work done on salt metabolism from this point of view; so that we must be guided entirely by what we have found to be the case.

If we accept anything like the usual figures given for the amount of fluid lost by the skin and the percentage of salt it is stated to contain—1000 c.c. of sweat containing 0·5 per cent. NaCl —it would mean a much larger amount of salt lost

[1] Crammer: Ueber die Beziehungen der Kleidung zur Hauttätigkeit, 1800.

per day than Crammer was able to find or than we have shown in the above investigations: for the very moderate figures taken it would be 5 grms. of NaCl daily. This, we consider, is an impossibility unless the NaCl is reabsorbed by the skin as evaporation of the sweat—invisible and visible—takes place. At all events our figures show that nothing like so much can have been excreted from the body by the skin in the case of the prisoners investigated.

In order to get some light on this point we carried out a few experiments to obtain the amount of salt excreted by the skin when profuse perspiration was present.

A man was thoroughly washed with soap and water and finally with distilled water; his loin cloth was similarly treated. He was then placed in a warm bath of distilled water and given hard work to cause sweating. The sweat was continually washed off into the bath, so that little or none of the salt could have been reabsorbed. The results showed that there was only a very trifling amount of NaCl excreted in the perspiration during the period he was under observation. This man, however, was only taking an moderate amount of salt—about 10 grms.—in his daily food. We may, therefore, conclude that under normal conditions an excretion of 2 grms. of NaCl by the skin is a large amount and a good deal beyond the average excretion.

We have further given proof that, under ordinary conditions of work and perspiration, the amount excreted by the skin varies directly with the total salt intake; and, with an intake of 20 grms. the amount eliminated by the skin is decidedly greater than Crammer found in severe muscular labour with profuse perspiration. We are, therefore, driven to the conclusion that 20 grms. of salt, from this point of view alone, is far beyond the amount the kidneys care to deal with.

It is quite evident from the investigations recorded that an addition of 10 to 12 grms. of NaCl in the daily diet provides all that is necessary for physiological needs, and that anything beyond this amount only causes a retention of fluids within the body with a fictitious advance in body-weight, thirst and diuresis. Bearing in mind what this means in the light of the researches of Widal, Marey and Mendel, that the ingestion of quantities of salt beyond what is necessary is not to the welfare of the body but much to the contrary, we would, therefore, recommend a reduction of the quantity sanctioned for prison diet scales from the present 25·4 grms. of added salt in the diet to at most 15 grms. of pure NaCl. This quantity is really much more than is necessary; however, with a purely vegetable diet more salt is required than in European diet scales.

We stipulate *pure* NaCl, as the salt in use in some of the jails is by no means pure. In Puri jail the material given contains only 84 per cent. of salt, and where country salt is used this statement holds good to a greater or lesser degree.

4. We now give an account of some observations carried out on two of the trained assistants engaged on these investigations, in order to determine the effects of varying the salt intake on the body-weight, and on the amounts of urine excreted.

No. I Assistant.				No. II Assistant.			
Day of experiment.	Quantity of urine.	Weight.	Intake of chlorides.	Day of experiment.	Quantity of urine.	Weight.	Intake of chlorides.
	C.C.	Lbs.	Grms.		C.C.	Lbs.	Grms.
1	1,420	127	20	1	1,360	154·5	25
2	1,610	126·5	20	2	1,930	154·5	28
3	1,410	127	20	3	1,390	53·9	25
4	1,220	126·5	20	4	1,410	154·2	25
5	1,790	128	20	5	2,190	154	25
6	1,470	127	20	6	..	..	*Nil*
7	1,380	26·5	20	7	1,080	153	,,
8	..	.	*Nil*	8	1,060	150	,,
9	880	123·5	,,	9	1,210	151	,,
10	800	123	,,	10	720	151	,,
11	790	123	,,	11	790	152	,,
12	900	122·75	,,	12	1,560	153	15
13	..	..	10	13	1,280	155	15
14	1,460	123	10	14	1,540	155	15
15	1,160	123¾	10	15	1,540	154	15
16	1,610	123¾	10	16	1,710	154	20
17	1,290	124	10	17	1,550	156	20

	Average daily urine c.c.	Average body weight lbs.
No. I Assistant—		
With 20 grms. NaCl added to his diet . .	1471	126·93
,, *nil* ,, ,, ,, ,, ,, ,, . .	842	123·06
,, 10 ,, ,, ,, ,, ,, ,, . .	1380	123·62
No. II Assistant—		
With 25·75 grms. NaCl added to his diet . .	1668	154·22
,, *nil* ,, ,, ,, ,, ,, ,, . .	976	151·40
,, 15 ,, ,, ,, ,, ,, ,, . .	1430	154·25
,, 20 ,, ,, ,, ,, ,, ,, . .	1630	155·00

These observations were most carefully carried out and are absolutely reliabl They confirm the results already obtained from work on prisoners. Anoth point of importance noted was that both Assistants got diarrhœa when 20 and 1 grms. of NaCl were added to their diet. Large quantities of salt have a wel known tendency to hurry on the food materials by increasing peristalsis of th bowel. This in itself is an indication for the cutting down of the very excessiv quantity of salt given in the jail diets—25 grms.

5. Investigations on five Bengali prisoners as to the elimination of sal when the quantities of Burma rice and Mung dal varied in each diet.

Diet I.

Burma rice	26 ozs.	observed for four days
Mung dal	6 „	

Total intake of salt = 485·00 grms.

Output in urine	414·45 grms.	=85·4	per cent.
„ in fæces	10·92 „	=2·2	„

leaving 12·4 per cent. eliminated in sweat or 2·98 grms. per man daily.

This corresponds with the results obtained on a similar diet in Puri Jai giving an average of 0·54 grm. in the fæces.

Diet II.

Burma rice	16 ozs.	observed for six days.
Mung dal	8·4 „	

Total intake of salt = 718·10 grms.

Output in urine	632·35 grms.	=88·06	per cent.
„ in fæces	26·46 „	= 3·7	„

leaving 8·24 per cent. eliminated in the sweat.

This means 0·88 grm. NaCl per man daily in the fæces, a higher figure than is usually obtained.

Diet III.

Burma rice	32 ozs.	observed for six days.
Mung dal	4 „	

Total intake of salt =638·10 grms.

Output in urine	536·25 grms.	= 84·04	per cent.
„ in fæces	11·40 „	= 1·78	„

leaving 14·18 per cent. to be eliminated in sweat.

This means that 0·38 grm. NaCl per man daily is passed in the fæces, a lower figure than is usually obtained.

Our reasons for giving this series are the increase in the amount of salt passed in the fæces when the dal is increased, and the diminished amount of salt present when the amount of dal is decreased. We found under the ordinary conditions of jail diet that the amount of salt appearing in the fæces was practically constant at 0·5 grm. per man daily; we now find that by varying the amount of dal in the diet a corresponding variation takes place in the elimination of salt in the fæces. This would appear to show that the salt of the fæces is largely derived from the dal in diets of the Lower Bengal type, and that dal is, therefore, less thoroughly digested and broken up than the other constituents of the diet.

A great many investigations besides those referred to have been made on the effects of increasing and decreasing the amount of salt in the daily food of prisoners; in fact, the estimations of the chlorides in the excreta were made in all the metabolism experiments. Nothing save the points already brought out in the examples we have given is at present evident.

One fact with regard to the Behari type of diet we may mention, *viz.*, that the amount of salt passed in the fæces is higher than in the diets of Lower Bengal, being nearly 1 grm. per man daily. This we would expect from the larger amount of salt contained in wheat and maize than in rice, and the greater actual amount of the diet that is unabsorbed and passed in the fæces. The outstanding features of the results of these investigations on salt metabolism are the very high degree of absorption of salt that does occur, and the comparatively small amount found in the intestinal excreta.

In Chart XV we give in graphic form the effects of varying the quantity of salt in the diet on the amount of salt eliminated by the skin, the quantity of urine excreted, and on the percentage body-weight.

CHAPTER V.

Some side-issues of the investigation.

1. The relationship, if any, that exists between the amount of urine passed and the quantity of rice in the diet.

A comparison of the urine excreted on different amounts of rice in the diets is only given when the conditions that obtained were, as far as possible, the same. The observations were carried out at the same time of the year when the temperature, humidity, etc., were fairly constant. The quantity of the salt given in the diet was always identical.

(a) Presidency Jail, Calcutta.

(i).—Five prisoners under observation for seventeen days.

		Per man daily.	Remarks.
1st period of five days.			
Diet—			
Burma rice	26 ozs.	Urine 1760 c.c.	Salt in diet a little higher than usual.
Mung dal	6 „		
2nd period of six days.			
Diet—			
Burma rice	16 ozs.	Urine 1573 c.c.	Ditto.
Mung dal	8·4 „		
3rd period of six days.			
Diet—			
Burma rice	32 ozs.	Urine 1958 c.c.	Salt usual quantity.
Mung dal	4 „		

These three results were obtained in August 1908, when the humidity was high and the variations of temperature and humidity small. If we neglect the action of the dal they would appear to show a relationship between the quantity of rice and the amount of urine excreted.

(ii).—Five Bengali prisoners under observation for twenty-two days.

		Per man daily.	Remarks.
1st period of twelve days.			
Diet—			
Burma rice	24 ozs.	Urine 1726 c.c.	Salt usual quantity.
Mottar and Massur dals	6 „		
2nd period of ten days.			
Diet—			
Burma rice	20 ozs.	Urine 1632 c.c.	Ditto.
Mottar and Massur dals	6 „		

These observations were made in October 1908 while it was still sultry, and they again show a decrease in the amount of urine passed when the quantity of rice in the diet was lessened.

(iii).—Ten Bengali prisoners under observation for fifteen days.

1st period of five days.		Per man daily.	Remarks.
DIET—			
Burma rice . . .	25 ozs.	Urine 2514 c.c.	Salt usual quantity.
Massur and Arhar dals .	6 ,,		
2nd period of five days.			
DIET—			
Burma rice . . .	20 ozs.	Urine 2545 c.c.	Ditto.
Massur and Arhar dals .	6 ,,		
3rd period of five days.			
DIET—			
Burma rice . . .	18 ozs.	Urine 1929 c.c.	
Massur and Arhar dals .	6 ,,		

These observations were carried out in the cold weather. The quantity of urine passed by the prisoners is very high. While the results with a diet containing 20 ozs. of Burma rice show practically the same quantity of urine excreted as with 25 ozs. those with 18 ozs. exhibit a great fall.

(iv).—That the quantity of dal does not seem to cause any variation in the amount of urine excreted would appear from the following :—

Ten Bengali prisoners under observation for fifteen days.

1st period of five days.		Per man daily.	Remarks.
DIET—			
Burma rice . . .	20 ozs.	Urine 2545 c.c.	Salt usual quantity.
Massur and Arhar dals .	6 ,,		
2nd period of five days.			
DIET—			
Burma rice . . .	20 ozs.	Urine 2544 c.c.	Ditto.
Massur and Arhar dals .	5 ,,		
3rd period of five days.			
DIET—			
Burma rice . . .	20 ozs.	Urine 2607 c.c.	Ditto.
Massur and Arhar dals .	7 ,,		

The average quantity of urine passed per day by these prisoners shows practically no variation for different quantities of dal, so long as the salt and rice of the diets do not change, and the climatic conditions are the same.

Note the very large amount of urine passed by these prisoners even during the hot months of the year. From the results stated it appears probable that a casual relationship can be traced between the amount of Burma rice in the diet and the quantity of urine excreted.

We have only one set of observations, in which different quantities of country rice formed part of the diets, other conditions all being identical.

(b) PURI JAIL.

Four prisoners under observation for ten days.

		Per man daily.	Remarks.
1st period of five days.			
DIET—			
Country rice . . .	26 ozs.	Urine 1807 c.c.	Salt 17 grms. daily.
Massur dal . . .	6 „		
2nd period of five days.			
DIET—			
Country rice . . .	20 ozs.	Urine 1512 c.c.	Ditto.
Massur dal . . .	6 „		

These observations were carried out in the cold weather in January 1909. They show a marked fall with a smaller quantity of rice, and also a far less amount of urine excreted than was the case with prisoners, who were under much the same climatic conditions, but were given Burma rice to eat.

(c) BUXAR JAIL.

(*i*) *Five prisoners under observation for fifteen days.*

		Per man daily.	Remarks.
1st period of five days.			
DIET—			
Burma rice . . .	14 ozs.	Urine 1929 c.c.	Usual quantity of salt.
Wheat ata . . .	10 „		
Mung dal . . .	6 „		
2nd period of five days.			
DIET—			
Burma rice . . .	12 ozs.	Urine 1865 c.c.	Usual quantity of salt.
Wheat ata . .	10 „		
Mung dal . .	6 „		
3rd period of five days.			
DIET—			
Burma rice . . .	10 ozs.	Urine 1697 c.c.	Ditto.
Wheat ata . . .	10 „		
Mung dal . . .	6 „		

In these observations the conditions were identical, except for the varying amounts of Burma rice. The same relationship is noticeable between the amount of rice and the quantity of urine excreted. Again will be evident the large amount of urine that these prisoners passed daily; the work was carried out in January 1909, *i.e.*, in the middle of the cold weather.

(ii) *Reference to table XI (Buxar Jail) bears out the same contention when the same batches of prisoners on varying amounts of Burma rice are taken.*

Thus—

BATCH X, TABLE XI.

		Per man daily.	Remarks.
DIET—			
Burma rice	14 ozs.	Urine 1929 c.c.	Usual salt.
Wheat ata	10 ,,		
Mung dal	6 ,,		
DIET—			
Burma rice	12·6 ozs.	Urine 1761 c.c.	Ditto.
Wheat ata	10· ,,		
Mung dal	6 ,,		

BATCH Y, TABLE XI.

DIET—			
Burma rice	12 ozs.	Urine 1893 c.c.	Ditto
Wheat ata	10 ,,		
Mung dal	6 ,,		
DIET—			
Burma rice	8 ozs.	Urine 1711 c.c	Ditto.
Wheat ata	10 ,,		
Mung dal	6 ,,		

(iii) *The only batch of prisoners in Table XIV—where varying quantities of rice with makkai ata were in use—shows the same thing.*

BATCH P.—TABLE XIV.

		Per man daily.	Remarks.
DIET—			
Burma rice	12 ozs.	Urine 2028 c.c.	Usual salt.
Makkai ata	10 ,,		
Mung dal	6 ,,		
DIET—			
Burma rice	10 ozs.	Urine 1871 c.c.	Ditto.
Makkai ata	10 ,,		
Mung dal	6 ,,		

The evidence obtained from investigations on the Behar prisoners in Buxar jail who ate Burma rice would thus appear to support the view that a relationship exists between the amount of rice in the diet and the amount of urine passed.

(d) Bhagalpur Jail.

Is the evidence of the Bhagalpur results of the same nature ?

(i) On Table XVI will be found Batch I—five Behari prisoners on similar diets, except for the varying quantities of country rice. They show the following results :—

TABLE XVI.

	Constants.			Varying quantities of country rice.		Quantity of urine per man daily.
Batch I.	Wheat ata . .	10 ozs.	+	Country rice .	14 ozs.	1622 c.c.
	Arhar dal . .	6 „		„ „ .	10 „	1557 c.c.
	Vegetables . .	6 „		„ „ .	8 „	1561 c.c.

Here is the same tendency to a diminished excretion of urine as appeared in the other results. In this case also the amount of salt in the diets was constant throughout.

(ii) Table XVIII has one batch of prisoners—Batch III—in which the only variation in the diets is in the amount of country rice. The following shows the results :—

TABLE XVII.

	Constants.			Varying quantities of country rice.		Quantity of urine per man daily.
Batch III.	Makkai ata . .	12 ozs.	+	Country rice .	14 ozs.	1340 c.c.
	Arhar dal . .	6 „		„ „	10 „	1280 c.c.
	Vegetables . .	6 „		„ „	8 „	1423 c.c.

The quantity of urine secreted by the batch when 8 ozs. of country rice was given is higher than with the other quantities, otherwise the results point to the same conclusion.

We may again call attention to the much lower quantity of urine passed by the prisoners in Bhagulpur jail than was the case in Buxar ; the same observation was made on comparing the quantities passed in Puri jail and in the Presidency jail, Calcutta. In Puri and Bhagulpur jails country rice was the variety in use whereas in the Presidency and Buxar jails Burma rice was given.

The climatic conditions were very similar so far as the investigations in Buxar and Bhagalpur jails are concerned, both jails being under investigation during the months of January and February 1909 when the air was dry and the temperature quite low for India.

From these observations it would appear probable that a larger quantity of urine is secreted when the intake of rice is high than when it is low. What the cause is—beyond the mere fluid taken in with the rice—it is difficult to say. If the cause were only the amount of fluid taken in with the cooked rice and the water capable of being formed from the constituents of rice, we should expect less fluids to be drunk, and that matters would thus right themselves. It seems possible, therefore, that rice *per se* has a diuretic action on the renal organs. Whether this is so or not, the evidence we have produced is strongly in favour of the view that the amount of rice present in the diet does influence in a marked manner the quantity of urine excreted. What its significance is, if any, we leave for the future to unfold, We may remark that we did not obtain anything like the same results regarding the amount of urine excreted when the dal, wheat or makkai ata of the dietaries were given in varying quantities.

2.—The relative influence, if any, on the excretion of urine exerted by Burma rice and Country rice.

Intimately connected with the apparent influence of large quantities of rice in increasing the flow of urine is the question, whether the two varieties of rice do so to the same extent.

It will be evident from the figures given in Chapter II and in Section I of this Chapter that, under as far as possible the same conditions, the amount of urine passed is, on the average, much greater when Burma rice is given than when country rice forms part of the diet.

From an analysis of all the results obtained, when the conditions of temperature, humidity, intake of salt and intake of rice were as nearly as possible similar, we have computed that the average amount of urine excreted by prisoners in the four jails examined was as follows:—

Presidency Jail, Calcutta	over	2000 c.c.	per man daily in the cold weather.
Buxar Jail, Behar	over	1800 c.c.	,, ,, ,, ,,
Puri Jail, Orissa	under	1600 c.c.	,, ,, ,, ,,
Bhagalpur Jail, Behar	,,	,,	,, ,, ,, ,,

That is, in the two jails where Burma rice was in use the average excretion of urine by the prisoners is on a decidedly higher level than in the two jails where country rice was the variety given in the dietaries.

This may be a mere coincidence and may have nothing to do with the different kinds of rice, being due to some other factor at present unknown. While we have no desire to draw any far-reaching conclusions from these results, we cannot help thinking that there is present in rice some substance that acts as a diuretic, and that this exists in greater amount in Burma than in country rice. What the significance of such a diuretic action may be we are at present

unable to say; but it will be readily admitted that if a diuretic influence does exist, its continuous action from the massive amounts of rice in the daily diet of Bengali prisoners cannot be for the welfare of the kidney epithelium. The supposed influence of Burma rice in the causation of Beriberi—a disease often associated with œdema—might form an interesting problem from this point of view.

In order to see whether the greater effect of Burma rice on the flow of urine would hold under absolutely the same conditions, two batches of prisoners in the Presidency jail, Calcutta, were kept under observation for a fortnight, one week on Burma rice and the next on country rice with the following results :—

One batch of the Bengali prisoners under observation for five days.

Diet—		Per man daily.	Remarks.
Burma rice	20 ozs.	Urine 2545 c.c.	Usual quantity of salt.
Massur and Arhar dals	6 „		
Vegetables	6 „		

The same men under observation for five days.

Diet—			
Country rice	20 ozs.	Urine 2015 c.c.	Usual quantity of salt.
Massur and Arhar dals	6 „		
Vegetables	6 „		

a difference of over 500 c.c. per man daily, seemingly due entirely to the variety of rice in the diet as all other conditions were absolutely the same.

We may, in connection with the effect of Burma rice on the excretion of urine, draw attention to the results shown on Table XXV. Here we had two batches of four men in each on a "meat" diet containing only 4 ozs. of Burma rice per man daily. The usual quantity of salt was given, and the observations were made at the same time as those recorded in this section. The results show a great diminution in the amount of fluid excreted, the average for the two batches over the period being 1284 c.c. per man daily, *i.e.*, only about half the amount excreted by the men on Burma rice 20 ozs. shown above. As would be expected there was a marked increase in the solid constituents of the urine—the sp. gr. ranging up to 1023 as compared with an average of 1008 for those on the rice dietaries.

3.—The quantity of fæces passed by prisoners on Bengal Jail dietaries.

(*a*) On diets of the Lower Bengal jail type—

(*i*) Five Bengali prisoners observed for 17 consecutive days, average weight of fresh fæces per man daily 14 ozs.

(*ii*) Twenty Bengali prisoners observed for 14 consecutive days, average weight of fresh fæces per man daily 15·2 ozs.

(*iii*) Sixteen Ooriya prisoners observed for twelve consecutive days, average weight of fresh fæces per man daily 14·1 ozs.

(*iv*) Four prisoners observed for eleven consecutive days, average weight of fresh fæces per man daily 14·4 ozs.

Therefore an average of—

5 × 17 = 85	14 ozs.
20 × 14 = 280	15·2 ,,
16 × 12 = 192	14·1 ,,
4 × 11 = 44	14·4 ,,

Total of 601 observations gives an average of 14·6 ozs. of fresh fæces passed per man daily.

These observations were made only when the prisoners were on the (practically) full Lower Bengal jail diet.

(*b*) When the amount of rice was reduced to *half* the ordinary quantity the weight of the fæces passed fell very considerably.

Thus—

(*i*) Four Ooriya prisoners observed for eleven consecutive days, average weight of fresh fæces per man daily 10 ozs.

(*ii*) This fall on decreasing the amount of rice is further shown in the following :—

Four Ooriya prisoners observed for five consecutive days.

DIET—

Country rice	26 ozs.	Fresh fæces 12 ozs. per man daily.
Arhar dal	3 ,,	
Vegetables	6 ,,	
Goat's flesh	4 ,,	

The same four prisoners observed for six consecutive days.

DIET—

Country rice	13 ozs.	Fresh fæces 6·7 ozs. per man daily.
Gram dal	3 ,,	
Vegetables	6 ,,	
Goat's flesh and fish	5 ,,	

(*c*) The quantity of fæces passed in diets of the Behari type—

(*i*) Thirty Behari prisoners under observation for a total of eighty-seven days—

DIET—

Country rice	16 ozs.	Fresh fæces 18·56 ozs. per man daily.
Different dals	6 ,,	
Wheat ata	10 ,,	
Vegetables	6 ,,	

This is decidedly higher than with the Lower Bengal jail type of diet.

(*ii*) This is also brought out in the case of Ooriyas when the ordinary amount of 26 ozs. of rice was reduced by half and wheat ata given instead.

Four Ooriya prisoners observed over eleven consecutive days, average weight of fresh fæces per man daily 16·64 ozs.

We may, therefore, conclude that the weight of fæces passed daily by prisoners on the Bengal jail dietaries is in round numbers one lb. per man daily, *i.e.*, from three to four times the weight of fæces passed ordinarily by a European on his diet.

A reduction in the quantity of rice entails a decrease in the weight of the fæces, but the weight of the fæces seems to be greater when wheat ata is substituted for an equal quantity of rice.

4.—The average amount of the nitrogen contained in the fæces.

In a large number of observations on the estimation of the total nitrogen of fæces we found the percentage of nitrogen present to be wonderfully constant and seldom very much outside the figures 1·2 to 1·8 per cent.

The average for some hundreds of estimations on the ordinary Bengal jail dietaries works out at 1·6 per cent. of nitrogen. If we calculate what this means for the amount of fæces passed by the Bengali and Behari it will be seen how very similar the figures are to those obtained from the urine method of estimating protein metabolism—

Thus, the Bengali passes 420 grms. of fæces, which would mean an average of almost 7 grms. of nitrogen per man daily, or about 50 per cent. of the total nitrogen of the diet.

The Behari passes 500 grms. of fæces, which would mean an average of about 8 grms. of nitrogen per man daily, or a little less than 50 per cent. of the total nitrogen of the diet.

These figures, which are only rough averages of a large number of observations, correspond with those obtained from the analyses of the urine taken in conjunction with the nitrogen intake ; *viz.*, a little over 50 per cent. of the protein of the Bengal jail dietaries is absorbed.

In connection with the more or less uniform percentage of nitrogen found in the fæces analysed it is worthy of note that some[1] writers prefer to speak of different foods as large or small fæces-producers, rather than as being capable of incomplete or complete absorption.

5.—The average amount of uric acid excreted in the urine by prisoners on the Bengal Jail diets.

It is universally accepted that the amount of uric acid in the urine depends on the nucleins and not on the ordinary proteins of the dietaries, so that the relationship between the total nitrogen and uric acid excreted has practically no significance. That is, the two methods of nitrogenous metabolism—purin metabolism and the general nitrogenous interchanges—are independent of one another.

[1] Hutchinson : Food and the Principles of Dietetics, also Prausnitz, Zeitsch, f. Biologie 1897.

In a purely vegetable diet such as that of the prisoners in Bengal a high uric acid excretion would not be expected, as vegetable food contains only small amounts of purin bodies. The pulses, however, do contain a fair quantity of nucleins.

We have made a good many observations on the amount of uric acid excreted by Bengali prisoners and find the quantity to be very much what would be expected from a vegetarian diet. Thus, in 690 uric acid determinations the amount excreted per man daily was, on the average, 0·44 grms.

The variations met with were small and never fluctuated for the Bengal types of diets outside 0·35 and 0·57 grm. per man daily. These figures include determinations on prisoners on both the Bengali and Behari types of diets—the interchange of ten ozs. of rice for ten ozs. of wheat ata does not appear to make any difference in the amount of uric acid excreted. The dals excepted, rice, wheat ata and vegetables may be looked on as almost forming a purin-free diet so that the uric acid is derived almost entirely from the dals—the exogenous—and from tissue metabolism—endogenous—the breaking down of nuclein-containing substances.

The method of estimation made use of in all our uric acid determinations was that introduced by Gowland Hopkins[1], which is by far the most accurate and simplest process.

6.—Xanthin or alloxur bodies or Purin bodies, including uric acid with a number of closely allied substances.

The Xanthin bases—xanthin, hypoxanthin, guanin and adenin—like uric acid have an endogenous source which is probably the nuclein of the tissue-cells, and an exogenous source furnished by the food-stuffs which contain nucleins and purins. According to Camerer, Salkowski, Walker, Hall and others the amount of xanthin bases in the daily urine amounts to from 30 to 50 milligrammes in Europeans.

We have carried out a number of observations with Walker Hall's purinometer and find the average quantity of purin bases excreted per man to be about 48 milligrammes per day. This amount seems rather high, but it represents about 9 per cent. of the uric acid excreted, on the same diet by the same prisoners, which is nearly the usually accepted amount. Von Noorden states that the quantity of these bodies rarely amounts to more than 8 per cent. of the uric acid excreted at the same time. Accepting Walker Hall's method as giving accurate results, it is very likely that the dals of the Bengali diet supply a fairly large amount of purin bases.

We did not go into any detail on this point, and simply state the results obtained from an investigation carried out on twenty prisoners observed for nine consecutive days.

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[1] Journ. of Path. and Bacteriology, 1893.

7.—The percentage of urea to the total excretion of nitrogen.

In a very large number of the observations in which the total nitrogen of the urine was determined, an estimation of the urea present was also made. The process followed was that of Mörner-Sjöqvist as modified by Bödtker[1] which gives accurate results.

Careful examination of our results as to the percentage of the total nitrogenous excretion that appears in the urine in the form of urea does not reveal any marked difference from the ordinary accepted standards.

The urea nitrogen is, however, higher than would be expected from a purely vegetarian diet.

In European diets the relative value of urea is given at 88 to 90 per cent. with flesh diet, 85 to 87 with a mixed diet, and about 80 per cent. with a vegetable diet. We find that on a dietary of the Lower Bengal jail type the percentage of urea-nitrogen is about 90 per cent. of the total nitrogen of the urine.

Twenty Bengali prisoners, observed during twelve consecutive days had their urine pooled: the nitrogen in the form of urea formed 90·1 per cent. of the total nitrogen of the urine.

We found, further, that the addition of a little meat or flesh made very little difference in the relative value of the urea; however, the amount of meat in the diets in the particular observations in which the urea was estimated was very small, and the diet could hardly even be called "mixed" in the European acceptation of the term.

On the whole we may say that in Bengalis a slightly higher percentage of the nitrogen of the urine is eliminated in the form of urea than is usually stated to be the case with Europeans on vegetarian or even mixed dietaries.

8.—The relation of ammonia nitrogen to the total nitrogen of the urine.

This is a side-issue to which we paid special attention, and a large number of observations were made on the quantity of free ammonia excreted by the prisoners on different diets.

In Europeans the quantity of ammonia excreted daily varies on a mixed diet from 0·6 to 1·0 grm. It is lower on vegetable, higher on animal foods. It is generally accepted that the quantity of ammonia nitrogen bears a certain relation to the total nitrogen, forming from 3 to 5 per cent. It is known that the cereals, by their freedom from organic alkaline compounds, do not alter the acid reaction of human urine, and do not diminish the excretion of ammonia, while green vegetables, with their high percentage of alkaline salts, do so in a most marked manner.[2]

Ammonia is a product of protein hydrolysis, and an increase in the amount of protein assimilated may lead in two ways to an increase in the excretion of ammonia; first, because, more protein being broken down, more of each of the

[1] Zeitschr. f. Physiol. Chemie. 1893.
[2] von Noorden: Physiology of metabolism.

hydrolytic products, and of ammonia with the rest, will be formed—this will not lead to any rise in the percentage of nitrogen passed out as ammonia; secondly because some of the ammonia, which would otherwise be passed out as urea, will be excreted in combination with the sulphuric and phosphoric acids formed by the breaking down of protein—this will lead to a rise in the percentage of nitrogen passed out as ammonia as well as in the absolute amount. The quantity of ammonia in the urine varies with the amount of acid radicles requiring neutralisation: if there be abundance of base taken with the food, less ammonia is required and it sinks to a low level in the urine. It does not, however, disappear entirely. The reason given for this by Spriggs[1] is that ammonia, being a normal metabolic product and therefore circulating in the blood, must pass through the kidneys: thus some of it will be excreted before it can reach the liver and have an opportunity of being turned into urea.

Investigations to determine the total amount and percentage of the nitrogen of the urine passed out as ammonia:—

TABLE XXIV.

(i) Twenty prisoners in the Presidency jail, Calcutta, were kept under observation for twenty days. The urine of these prisoners was pooled and samples tested for ammonia. Special care was taken in all these investigations to see that no decomposition had taken place. Usually the samples were put up immediately at the end of the twenty-four hours' collection, and no sample was accepted unless it was acid in reaction.

Batch.	Average quantity of urine per man daily.	Average total N. of the urine per man daily.	Average NH_3 per man daily.	Total N. of urine for period.	Total NH_3 of urine for period.	Total N. NH_3 for period.
	C. C.	Grms.	Grms.	Grms.	Grms.	Grms.
Twenty Bengali prisoners	2406	8·09	1·01	150·20	14·45	11·90
	1754	8·91	·95			
	1840	8·90	1·16			
	1803	9·18	·96			
	1862	9·79	·90			
	1925	9·81	1·09			
	1707	9·73	·68			
	1974	9·45	·90			
	2070	9·09	1·02			
	1976	8·40	·85			
	2066	8·87	·70			
	1943	8·85	9·2			
	2063	8 05	1·01			
	1892	7·52	·47			
	1754	7·69	·47			
	1920	8·43	·56			
	2057	9·44	·80			

[1] Spriggs: Med.—Chi. Trans. Lond. 1904 LXXXVII, p. 325.

From these figures we find that the percentage of the total nitrogen excreted in the form of ammonia is 7·92 or 0·85 grm. per day. This is decidedly higher than would be expected from the results given for Europeans.

The diets on which some of the prisoners were during these observations contained meat and fish, so that they were not entirely vegetable in character.

(*ii*) Twenty Behari prisoners under observation for fifteen days : the urine was pooled and samples tested for ammonia.

The diet consisted of Burma rice, wheat ata, mung dal and vegetables—no meat or fish was given.

Results tabulated in three periods of five days in each.

BATCH.	Average quantity of urine per man daily.	Average Total N. of urine per man daily.	Average NH_3 per man daily.	Total N. of urine for period.	Total NH_3 of urine for period.	Total N. NH_3 of urine for period.
	C. C.	Grms.	Grms.	Grms.	Grms.	Grms.
Twenty prisoners Beharis	1895	8·52	·782	26·48	2·451	2·018
	1756	8·65	·804			
	1760	9·31	·865			

From these figures we find that the percentage of the total nitrogen that is excreted in the form of ammonia is 7·62 or 0-817 grm. per man daily. This percentage is again higher than would be expected.

(*iii*) Twenty Behari prisoners in Bhagulpur jail under observation for fourteen days ; the urine was pooled and samples tested for ammonia.

The diet consisted of the ordinary Behari constituents—no flesh or fish being added.

In all forty-five NH_3 determinations were made on the pooled urine with the following results :—

Average quantity of urine per man daily.	Average total nitrogen per man daily.	Average NH_3 per man daily.	N—NH_3 per man daily.
C. C.	Grms.	Grms.	Grms.
1570	9·26	0·829	0·682

That is the percentage of the total nitrogen that is eliminated in the form of ammonia is 6·82 or 0·829 grms. per man daily.

i. By collating these results we see at a glance their full import—

(i) 20 Bengali prisoners on mixed diet excreted 0·85 grm. NH_3 per man daily, which is 7·92 per cent. of the total nitrogen of the urine.

(ii) 20 Behari prisoners on Behari diet excreted 0·817 grm. per man daily; which is 7·62 per cent. of total nitrogen of the urine.

(iii) 20 Behari prisoners on Behari diet excreted 0·829 grm. per man daily, which is 6·82 per cent. of the total nitrogen of the urine.

While the observations show that the addition of meat and fish causes a higher actual and relative excretion of nitrogen in the form of ammonia—and in the Bengali prisoners on mixed diets this would have been still more marked, had it not been that certain diets containing no animal food are included—the important point would appear to be the consistently high proportion of the total nitrogen that is eliminated in the form of ammonia, whatever the diet may be. It will be further noticed that this proportion is lower the higher the level of nitrogenous equilibrium reached, *i.e.*, the percentage of nitrogen eliminated as ammonia varies inversely with the total nitrogen excretion.

The question naturally arises as to the explanation of this high ammonia factor in the urine compared with the generally accepted 3 to 5 per cent. in Europeans. If we had found a low percentage of the nitrogen excreted in the form of urea we might have looked on a relative acidosis as affording a plausible explanation; but such we have seen not to be the case. We have no explanation to offer further than to remark that it has been noticed by other observers that a fall in the level of nitrogenous metabolism to 7 or 8 grms. seems to be accompanied by a rise in the proportion of ammonia—as a normal event, and quite apart from the presence of urinary organic acids[1]. While this may be true for Europeans we are more inclined to believe that intestinal putrefaction and the absorption of indoxyl[2] compounds requiring for their neutralisation strong bases, and among these ammonia, is a much more likely explanation. This view is borne out by the researches of Dr. I. M. Mullick[2] on the urine examination of some 500 students and seemingly healthy individuals in Calcutta, amongst whom he found that about 40 per cent. had indican in their urine much in excess of what may be considered the normal amount.

9.—The relative absorption of protein from a diet containing an animal protein by Hindus and Mahomedans.

It is generally believed that Mahomedans, who are accustomed to an animal protein in their daily diet, are better able to absorb the protein from an animal food than are the Hindus who are very largely vegetarians.

[1] Spriggs: Quarterly Journal of Medicine, April 1909.

[2] Mullick: Calcutta Medical Journal, May 1909.

In order to obtain some information on this problem the following investigation was carried out :—

TABLE XXV.

Two batches of prisoners—one Hindu, one Mahomedan—were put on exactly the same diet for three days before the collection of their urine began.

The diet was—

Bread	8 ozs.	Calculated value of this diet in nitrogen 16·29 grms.
Mutton	12 „	
Fish	6 „	
Rice	4 „	
Potatoes	4 „	

Four Hindu prisoners observed for five consecutive days.

Batch A.	Quantity of urine.	Weight of prisoners.	Total N. of urine.	Value of diet in nitrogen for batch.
	C. C.	Lbs.	Grms.	
Four prisoners, Hindus	6830	124·2	49·43	65·16 grms. each day.
	6500	124·1	49·32	
	4980	124·1	50·33	
	5040	124·2	61·88	
	5470	124·1	56·51	

Four Mahomedan prisoners observed for five consecutive days.

Batch B.				
Four prisoners, Mahomedans	6450	124·3	50·25	65·16 grms. each day.
	4170	124·3	48·74	
	3970	124·2	55·64	
	3920	124·3	60·52	
	4020	124·2	55·66	

What do we learn from these results ?

BATCH A—

Total nitrogen of urine	267·47 grms.
Constant 0·5 grm. per man . .	10·00 ,,
Total nitrogenous metabolism . .	277·47 ,,
	=13·87 grms. of nitrogen per man daily.
	=85·16 per cent. of the nitrogen of the diet.

BATCH B—

Total nitrogen of urine	270·81 grms.
Constant 0·5 grm. per man . .	10·00 ,,
Total nitrogenous metabolism . .	2808·1 ,,
	=14·04 grms. per man daily.
	=86·19 per cent. of the nitrogen of the diet.

That is, practically identical results are obtained for the two classes when they are on the same diet for the same length of time and under the same conditions. So that it would not appear that the Mahomedan absorbs a higher percentage of the protein in a diet containing a large amount of animal food than is absorbed by the Hindu.

Another point brought out in this observation is the high percentage of protein absorbed from a diet which may be considered almost European in type. It is doubtful if much better absorption could take place from a diet of this kind than that shown by these batches of Hindus and Mahomedans. So that we are fairly justified in opining that the degree of nitrogen absorption depends largely on the manner in which the protein of the diet is made up, and not on the absorptive power of the intestinal tract of one class of people being much superior to that of another class.

Voit[1] and Craemer[2] discovered many years ago that persons who have been for years accustomed to one form of diet absorb its constituents no better than those to whom such a regimen is a comparative novelty. Further, the large number of observations which have been made on different persons with common articles of food have failed to elicit any striking disparity in the degree of absorption.[3] From the results of the present investigations we are in a position to endorse these opinions to a very great extent; the exceptions would appear to be brought out by a comparison of the absorption obtained from the people of the plains and the hill-tribes of Bengal.

To this, however, we shall return in Part II.

[1] Voit: Zeit. f. Biologie 1889.
[2] Craemer. Zeit. f. physiolog. Chemie. 1882.
[3] Hutchinson: Food and Dietetics

PART II.

The relationship of Food to Physical Development.

"It is food that supplies the material for that perpetual series of transformations in which life consists, and it must be adequate in quantity and suitable in quality if these transformations, of so many different kinds, in so many different organs, are to proceed with that nicely balanced adjustment that is known as health; nutrition is therefore an important branch of preventive medicine." [1]

In our work so far we have had no necessity to face the much-discussed question raised by Chittenden, *viz.*, what is the proper daily protein intake necessary to meet the needs of the body? Much has been said, and well said, for and against the views put forward by Chittenden. In the presidential address from which we quote above, published in the Journal of the Royal Institute of Preventive Medicine, Sir J. Crichton-Browne deals with the evidence for and against in a masterly manner. His general conclusions—and in these he is in agreement with most European physiologists, so far as Europeans are concerned—are that Chittenden's views and standards cannot be accepted in their entirety. At the same time it must be admitted that in the "Physiological Economy in Nutrition" and in "The Nutrition of Man" Chittenden makes out a very strong case, founded on the most painstaking and laborious experimental study. In some researches [2] on the metabolism of the Bengali and on his nutrition, we have shown that the average native of Bengal on the ordinary diet of the province—rice and dal—reaches an even lower limit of nitrogenous metabolism than any of Chittenden's subjects. We found that students and members of the fairly well-to-do classes exist on a metabolism of less than 40 grms. of protein per man daily. The great mass of the population are on an even lower scale than this.

These results bear out Chittenden's views as regards the possibility of man existing on a protein content of the general diet less than one-half of the ordinary standards and, so far as that goes, we freely admitted that the protein metabolism of the Bengali confirmed and corroborated his opinion.

It was when we tried to judge the effects of this dietary on the physical development of the race, their capacity for manual labour, the condition of their blood and tissues, and above all their resisting power to disease and infection, that we were forced to part company from Chittenden and the opinions he has expressed with regard to the great beneficial effect of a reduction of protein on mankind. We showed—by observations on students, prisoners and servants of this College

[1] Sir J. Crichton-Browne: Parcimony in Nutrition, Presidential Address to the Section of Preventive Medicine. Journal, August 1908.

[2] Scientific Memoirs No. 34. Government of India.

and by an analysis of the records of the physical development of Bengali and Anglo-Indian students in the same College, under the same climatic conditions, doing the same work, but on a different diet—the miserable standard of the Bengali's physical development, seemingly entirely due to the low scale of protein absorption. Without entering into any detail of the work carried out on these lines we may state that, from the evidence brought forward, we had to admit that, while it is quite possible for an individual or the members of a whole race to live on the metabolism of 6 grms. of nitrogen daily, the results of this on their general well-being, health, physical development, vigour, resistance to infection or even immunity from kidney disease were not such as to confirm a belief in the sufficiency of Chittenden's standards.

In our work on the nutritive value of Bengal jail dietaries we were relieved from all necessity of looking at this side of the problem. The prison diet scales have now been in use for over twenty years and there has never been any doubt as regards their sufficiency, the general opinion, on the contrary, being that they were much more liberal than was necessary.

Accepting the established fact, therefore, that the dietaries were sufficient, all we had to do was to estimate the average level of nitrogenous metabolism from those scales, and use this as our standard of the protein requirements of Bengali prisoners.

In accordance with our belief in the favourable influence of an excess of protein over bare sustenance, it has been our object in framing new diet-scales to raise the level of protein metabolism for both Bengali and Behari, by suggesting measures to decrease the bulk of the diet, and thus permit of a better absorption and, at the same time, to add some of the more easily assimilated proteins such as are furnished by wheat ata or an animal protein to their dietaries.

It will, therefore, be evident that our proposals are in direct opposition to the views expressed by Chittenden and his followers. According to his results the metabolism of 0·12 grm. of nitrogen per kilo of body-weight daily is all that is necessary for the protein requirements of the body. "These are perfectly trustworthy figures with a reasonable margin of safety and carrying perfect assurance of really being more than sufficient to meet the true wants of the body, adequate to supply all physiological demands for reserve protein, and able to cope with the erratic requirements of personal idiosyncrasies."

How do our results and proposals compare with this standard?

We have seen that the average nitrogenous metabolism of Bengali prisoners on Lower Bengal jail diets works out at 7·55 grms. per man daily.

From analyses of over 30,000 weighments[1] the average weight of the prisoner is 50·0 kilos. This means the metabolism of 0·15 grm. nitrogen per man daily—

[1] Scientific Memoirs, Government of India, No. 34.

a quantity that Chittenden would consider excessive, particularly so, when the large carbohydrate and fuel value of their present dietaries is taken into account.

The Behari, we found, averaged a nitrogenous metabolism of 9·50 grms. per man daily ; his body-weight may be taken in round numbers to be, on the average, 55 kilos. This means the metabolism of 0·173 grm. of nitrogen per man daily, again very much in excess of what Chittenden would consider the protein requirements of the body.

Our proposals would increase the nitrogenous metabolism of the Bengali on the Lower Bengal diet up to 9·00 grms. per man daily or 0·180 grm. nitrogen per kilo of body-weight, while the suggested diet scale for the Behari would permit of a nitrogenous metabolism on even a higher level than at present.

The effects, therefore, of the proposed changes in Bengal jail diets would be to increase very considerably the protein metabolism of the Bengali and slightly so that of the Behari, while at the same time getting rid of some of the excessive carbohydrate and heat value of the dietaries, the beneficial effects of which we have already fully discussed. This is entirely at variance with Chittenden's views, as according to his standards the dietaries are already excessive in both protein and carbohydrate. The question, therefore, arises, is there any necessity to raise the level of the protein metabolism of the prisoners ?

We have given one very good and sufficient reason, *viz.*, the urgent necessity to obtain a higher percentage of protein absorption and thus reduce to as low a figure as possible the large protein waste by the bowel, thereby lessening putrefaction. This we have shown can be done by decreasing the rice and dal of the Bengali diet, and the rice of the Behari. The necessity of raising the level of nitrogenous metabolism by the addition of a more assimilable protein is on a different footing, and to a consideration of this question we shall now turn.

We shall not go into details regarding the criticisms that have been made on Chittenden's proposals, or the experimental evidence that has accumulated against them ; we shall content ourselves with stating the results obtained from our work in Bengal, and the practical deductions to be drawn therefrom.

One or two points we should like, however, to refer to as they will be found to have a somewhat close relationship to the conditions present in Bengal.

Chittenden's standard of protein food is less than one half of that of Voit, and conflicts violently with the common practice of the majority of mankind. "It is an initial objection to Chittenden's views which is not easily met, that it contravenes all human experience. If he is right, then all the world up to this time has been wrong. It is *Chittenden contra mundum*.............deep down beneath all superficial fluctuations and gradual evolutions there are certain fundamental,

instinctive nutritional demands that cannot be interfered with without risk. These are embodied in old time tradition and customs, and one of these is a demand for a protein intake much more than double, indeed nearly treble, what Chittenden would allow."[1]

How do these hereditary instincts and customs in the formation of his dietetic habits and in the choice of food stand with respect to the Bengali? We may at once say that another factor, and a very important one as regards the great mass of mankind, comes in, *viz.*, the cost of food materials.

The Bengali lives on the cheapest food available and, in a country not yet thoroughly opened up, the cheapest food is usually the home-grown product. We, therefore, find the Bengali living almost entirely on his home-grown rice and dal; the Behari on his home-grown rice, dal and ata; the hill tribes, which we shall have to deal with separately in this connection, are not satisfied with these simple vegetable materials but demand a much more varied and costly diet.

The Bengali or Behari is in the great majority of cases only a vegetarian by force of circumstances: where he can afford other additional items as fish, milk or mutton, he readily avails himself of the opportunity of thus increasing his assimilable protein intake. This desire for nitrogenous food and particularly food of an animal nature was well brought home to us in the feeding experiments on prisoners, when the promise of meat, or the threat of withholding it, was quite sufficient to induce the prisoners to carry out without a murmur whatever was desired of them. It was further exemplified by the difficulty that we sometimes experienced in having fish or meat cooked without a fair proportion of it disappearing; this necessitated our having to place guards over the meat until it had been distributed to the batches for whom it was intended. The great mass of the people, however, can only afford the cheap home-grown rice and dal with occasional additions of more palatable elements. Their instincts, therefore, for a better form of dietary are held in check by an inability to meet the cost of gratifying them. In order to make up in quantity for deficiency in quality we find that the Bengali has accustomed himself to consume what to a European seem enormous quantities of rice and even dal; the same also is true to some extent of the Behari.

We know what the results of this limited diet of rice and dal in the Bengali, or rice, dal and ata in the Behari mean as regards the level of nitrogenous metabolism. We have shown previously that the average amount of protein undergoing metabolism in the case of the Bengali reaches the very lowest physiological limits: in fact it would be more accurate to call it almost protein starvation. This is not by any means so marked in the Behari, who, with part of his diet made up of

[1] Sir James Crichton-Browne: *loc. cit.*

the more assimilable protein of wheat ata, is placed on a higher level of nitrogenou metabolism.

We may conclude, therefore, that the people of the province of Bengal a largely vegetarians, but are so only through force of circumstances—that they liv on what they are able to obtain, and not on rice and dal from free choice; tha given the opportunity of obtaining animal food, they readily and greedily ava themselves of it; that, in order to provide for an absorption of protein attainin even the lowest physiological limits, very large quantities of rice and dal have to b consumed—so large, as we found in the case of prisoners, that the actual bulk c the diet interferes with its absorption. While this is true for the mass of th population it is more particularly so for the inhabitants of Lower Bengal, and to less extent for the Behari.

What are the effects on the general well-being of the people of these compul sorily limited dietaries, which are characterised not so much by a deficiency i the amount of protein they offer, as by the exceedingly poor protein absorptio possible from them?

Before going on to contrast the effects of these diets on the Bengali and Behari respectively, we should like again to refer to another grave objection brought agains Chittenden's standards.

"It is obvious that in the study of dietetic customs those most widely dissemi nated and followed by many races and vast populations are of higher validity tha those confined to small communities, and further, that the practices of the more successful races and the more affluent classes of a nation are more likely to yield good dietetic models than the practices of the more backward races and poorer classes. The former have greater freedom of choice, and their success in the struggle for existence is evidence of the suitability of their food habits. All the successful races have habitually consumed protein far in excess of what was required for tissue repair and far in excess of Chittenden's standard, and when we find a definite relation between protein consumption and racial success that is good ground for believing that behind it there is a biological law."[1]

Further, Benedict[2] states "Dietary studies all over the world show that in communities where productive power, enterprise and civilization are at their highest man has instinctively and independently selected liberal rather than small quantities of protein." He instances the immense improvement that takes place both in physique and morale of the negro and "poor white" of the Southern States, and the Italian labourer in South Italy, when fed on a higher protein diet.

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[1] Sir James Crichton-Browne: *loc. cit.*

[2] Benedict: Am. Journ. of Physiology.

Nitti [1] expresses the conviction that the proportion of protein in a diet is one of the great determining factors in the productive capacity of a nation. We need hardly instance, in this connection, the rapid and remarkable rise of Japan amongst the nations coincident with a vastly increased consumption of animal food, or the recorded fact that during the late war the Japanese troops had a more abundant protein diet than any other army in the field has ever enjoyed.

There is, therefore, a fairly general consensus of opinion that the sociological conditions, enterprise, vigour and physical development of a people are intimately bound up with the quantity of assimilable protein in their dietaries. These influences of dietaries, and the effects of the different amounts of protein offered capable of absorption, are remarkably well brought out by a study of the general status and physical welfare of the different classes of the inhabitants of Bengal.

I. *The Bengali.*—In our work on the nutrition of the Bengali,[2] already more than once referred to, we showed, from observations on the urine and blood, how very low the level of interchanges going on within the body was—the total nitrogen undergoing metabolism being only about one-third that of Europeans. The only comparatively high figure we obtained was for sulphates, pointing to a higher degree of intestinal putrefaction in the Bengali than in Europeans.

Similarly with regard to the chemical analysis of the blood we found a higher percentage of water and a lower percentage of total solids and protein: the hæmoglobin was markedly reduced and the blood pressure was on a distinctly lower level. We found that the result of these conditions was markedly to modify the physiological requirements of nutrition and, to a considerable extent, affect the growth and power of muscular contraction of the average individual, whose nitrogenous tissues are not given the option of drawing their nutritive material from so rich a source, nor have they the same opportunity of obtaining as free a supply of oxygen. We concluded from this study that a people on a diet, from which only 37·50 grms. of protein are absorbed, live in a more or less chronic state of nitrogen starvation, leading to a loss of body-fat and tissue-protein with an accompanying loss of vigour and strength and a comparatively low capacity for prolonged or sustained muscular effort. From the evidence as to physical development we showed that the general physique of the Bengali was on a par with his diet, and that a close relationship existed between the poor physical development of this people and the meagre protein absorption possible from the diet on which they subsist.

This was particularly well brought out by an analysis of the recorded weighments, chest measurements, and heights of Bengali and Anglo-Indian students

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1 Nitti: The Economic Journal, 1896.

2 Scientific Memoirs: No. 34.

during the several years of attendance at one of the residential Colleges in Calcutta. Under the same conditions but on different diets we saw that :—

(*i*) Compared with an average increase in body-weight of 2 lbs. in the case of the Bengali students on their diet, there was an average increase of 14 lbs. in Anglo-Indian and Eurasian students over similar periods.

(*ii*) Of the Bengali students 42·8 per cent. showed a diminution of weight compared with 2 per cent. amongst the Anglo-Indian students, in a comparison of the weights on entrance and at the end of the third year : of the Bengalis only 15·3 per cent. gained weight continuously at College, whereas practically all gained weight continuously amongst the Anglo-Indian students.

(*iii*) The chest measurements bear out the same conclusions : the Bengali practically remains unaltered, whilst the Anglo-Indian increases his chest-girth very considerably.

The diets on which these results were obtained were :—

I.—Bengali Students.		II—Anglo-Indian Students.	
Protein 67·11 grms. (of which 9·3 grms. were derived from an animal source).		Protein 94·97 grms. (of which 38·32 grms. were derived from an animal source).	
Carbohydrate . .	548·73 grms.	Carbohydrate . .	467·00 grms.
Fat . . .	71·55 ,,	Fat	56·20 ,,

Comment on these results is unnecessary. The figures were obtained from the records of the medical officer of the College and were worked out in collaboration with F. E. Dempster, Esq., C.I.E., who makes statistical work one of his hobbies. They show very conclusively the results to be expected in growing lads from diets deficient and rich respectively in absorbable protein.

The further evidence brought forward regarding the physical endurance, capabilities of performing work and the experience of life insurance companies, all place the Bengali on a low plane of physical development. The general consensus of opinion also showed that his power of resistance to disease was markedly inferior to the more highly-fed European. Even in the very condition that Chittenden lays such stress on as most likely to be avoided by a decrease in the protein intake, *viz.*, renal disease, we find the facts do not bear out his contention ; renal disease being more common amongst the ordinary working population of Bengal—and very much more so amongst the higher classes in combination with diabetes—than amongst Europeans in Europe or India. This is all the more remarkable in a country where scarlet fever is unknown, and amongst a people where the consumption of alcohol is, comparatively speaking, negligible.

The general conclusion to be drawn from these investigations on the Bengali is that his physical development—the actual amount of protoplasmic tissue as distinguished from fatty tissue—is only such as could be expected from the miserable level of nitrogenous metabolism to which he attains—is on a par, in fact, with his diet.

We have seen that the average Bengali's nitrogenous metabolism is 6 grms. per day—the prisoner's being 7·55 grms.—and that it is our aim to raise the latter to 9 grms., or 0·180 grms. per kilo of body-weight.

II. *The Behari.*—We have no very detailed study of the Behari to present, but such is not absolutely essential for our present purpose. As admirably pointed out by Benedict, experimental evidence is rapidly accumulating to show that the quantity of food required has a very intimate relation to body-weight, and that the actual amount of protoplasmic tissue apparently exercises a marked influence on the food requirements. The converse of this most certainly holds in the development of the individual and in different races, *i.e.*, the muscular development may be looked on as a function of the diet or, more particularly, of the absorbable protein of the diet. In this connection we may instance the bountiful supply of protein provided by nature in the milk of the mother for infant nurture; the success that has attended the treatment of consumption and other diseases by the systematic administration of a diet of high nutritive value; the remarkable results obtained by the Weir-Mitchell line of treatment: in all of these the protoplasmic tissues are being built up by increasing the nitrogenous intake, in some cases, enormously. Further, it is very probable that the great decrease in the incidence of phthisis in England is largely due to the superiority of the present-day dietaries of the mass of the population.

When we examine the Behari and contrast him with the Bengali we find that he obeys the same biological law—his protoplasmic development is a function of the absorbable protein of his diet. We have seen that the Behari jail diet provides for a level of nitrogenous metabolism which is 2 grms. per man higher than the Bengali diet. Accepting the same average for the food of the people of Behar generally, this would mean the metabolism of 8 grms. of nitrogen (the Bengali's being 6 grms. daily). That is, the level of nitrogenous metabolism is at least 20 per cent. higher in the Behari than in the Bengali. In accordance with this we find in the Behari a much better physical development, greater capabilities for muscular exertion, a distinctly greater degree of vivacity, briskness and sprightliness of manner. The body-weight, and, what is really of most importance, the actual quantity of protoplasmic tissues, is also on a higher scale of development. It may be taken that the average weight of the Bengali is to that of the Behari as 110 lbs. to 120 lbs. This difference of 10 lbs. on the average is practically entirely to

be accounted for by the greater muscular development—the framework, etc., in the two people being, to all intents and purposes, the same.

When we come to an examination of the hill tribes it will be seen that the characteristics mentioned above, the beginnings, as it were, of which are to be found in the Behari, are exceedingly prominent in the people around Darjeeling. They are so much in evidence that, if there were no other differences, they would form an outstanding feature of demarcation between the Bengali and tribes living on a highly assimilable protein diet. In the hill people there are no signs of the slackness, want of vigour, tonelessness, general slowness of reaction, and other physiological attributes difficult to describe, detect and measure, which, to those who have lived amongst the people of Bengal, form some of the distinguishing characteristics of the ordinary working population. Self-absorption and want of interest in the incidents of every-day life, little power of attention, observation or concentration of thought—these are some of the attributes of all but the better classes and better-fed of the Bengalis.[1] The Behari does not show these characteristics to anything like the same extent, and for these and other reasons we may place him on a scale superior to the Bengali but inferior to hill men. We consider it will be readily admitted by those who have lived amongst both races that the Behari is, on the average, by fully 20 per cent. a more capable individual than the average Bengali of the same class.

Now the question arises: Are there any other factors except differences in diet that will satisfactorily account for this higher level of physical development and general well-being? We believe that the presence of wheat as a component part of the diet sufficiently explains the situation; however, we shall examine some of the objections that have been brought against the view that defective nutrition results from a low protein intake.

Dr. J. H. Kellogg, perhaps one of the strongest vegetarian advocates in the United States, favoured us, through Professor Benedict, with the following criticism of our finding, regarding the important rôle played by diet, and especially protein, in the nutrition of the Bengali, published in the memoir already referred to:—

"The weakest part of the report from my standpoint is the remarks which the investigator makes in relation to the defective nutrition resulting from the low protein dietary. I do not think it is at all fair to attribute the lack of endurance often seen among the Indians to the low protein diet. There are so many factors which certainly should be taken into consideration: among these are their sexual excesses, the depressing effects of the very hot, damp climate in which they live and which predisposes to lack of exercise, the injurious effects of excessive

[1] The inhabitants of Bengal who live close to the sea-coast and rivers are said to be much more muscular and capable of performing much more work than those inland; fish forms a large part of the diet of the class referred to.

prolonged exposure to the actinic rays of the sun, the cause of debility to which Professor Woodruff of the United States army has been calling attention with some considerable show of evidence. Still another factor of importance is the immature age at which these people usually marry. Many of the Indians, however, are strong and robust people. I understand that an Indian regiment made up entirely of natives is the finest lot of men in His Majesty's Service."

Now in this apparently fair and honest criticism there are put forward several definite causes to account for the acknowledged low standard of nutrition in the Bengali, with its accompanying inferior muscular development, lack of endurance, and poor capacity for work.

To enumerate these,—Dr. Kellogg thinks that sexual excesses, bad climate actinic rays of the sun, immature age of marriage are causes of more importance than diet in the defective development of the Bengali.

We agree that these causes have undoubtedly an influence in retarding growth and lowering the general standard of physique, and, if there were no means of estimating their effects, it would be very difficult to say that they are not quite sufficient—as Dr. Kellogg believes—to account for the relative differences between Bengalis and Europeans.

Many objections to them immediately arise, for instance as regards climate and the actinic rays of the sun—Europeans, Eurasians and the better-fed Bengalis all are equally exposed to these influences, yet retain their energy. Sexual excesses we have enquired into, and, while masturbation may be, and probably is, more prevalent, excessive sexual congress is chiefly practised by the better classes who can afford luxuries and possess the stamina fully to satisfy their desires. Immature marriage is undoubtedly a factor, but there are customs with a tendency to neutralise its ill-effects: the husband and wife do not live together until the wife reaches puberty—the husband is usually several years older than the wife, and the wife spends about one-third of each year away from her husband at her father's house or with relatives. Another effort of nature to maintain the standard is shown by the relatively higher death-rate amongst the children born early in marriage life; in fact the death-rate amongst children in a large city like Calcutta is appalling—showing the weeding out of degenerates in a very thorough manner. But, while these replies to Dr. Kellogg's criticisms are important in showing that his objections do not cover the whole ground, it is evident that they are too indefinite to be measured and appraised at their full value, which would, even at the best, be only a matter of opinion, one school of thought looking on them from a point of view different to that of another school.

In order, therefore, to get more definite and precise information as to the effects of diet *per se* we have extended our enquiries to different tribes—and in

future will do so to different races—in which the several factors enumerated by Dr. Kellogg are common to all, the dietaries forming the main point of difference. In this way we can eliminate the influence of the sun's rays, early marriages, climate, sexual excesses, etc., in fact everything except the rôle played by diet—or more particularly, absorbable protein—in the different conditions that go to make one class superior to another, or one tribe or race superior to another tribe or race.

At present we are dealing with the Bengali and Behari, and we have no hesitation in stating that the Behari is a stronger, healthier, more capable individual in every respect than the Bengali—when the same classes are compared, such as the working cooly or the average prisoner in the jails of Lower Bengal and Behar.

This fact is evidenced by the Beharis' higher body-weight, and even stronger grounds for this opinion are afforded by the general appearance and demeanour of the two classes. They are altogether brighter, fitter and more energetic in their movements.

The only possible explanation of these differences from Dr. Kellogg's standpoint would be the influence of climate. Behar is drier than Bengal, and has a temperature slightly lower in the cold weather, but much hotter during the summer.

The differences in climate, however, are only marked between the extremes of Bengal and Behar, whereas wherever we find a change from a diet of rice and dal to one containing wheat in addition the superiority of the Behari at once becomes evident.

All the factors that Dr. Kellogg lays stress on are present in both Behar and Bengal and cannot account for the inferiority of the Bengali in physique and general capabilities.

It may be concluded—so far as the evidence obtained by contrasting the Bengali and Behari goes—that diet appears to play the principal part in the formation of their respective characteristics and general bearing. The difference in diet, as we have seen, is the substitution of a certain amount of wheat ata for rice or—translated into its ultimate effect—the metabolism of from 8 to 9 grms. of nitrogen daily for the average Behari, in place of the metabolism of from 6 to 7 grms. of nitrogen daily for the average Bengali. This line of investigation we hope to work out fully for some of the finer races of the plains of India and more particularly of the Punjab; at present we must rest content with the evidence afforded by the metabolism of the Bengali and the Behari.

Before passing on to a study of the hill tribes we shall take up the last part of Dr. Kellogg's criticism, *viz.*, "many of the Indians, however, are strong and robust people. I understand that an Indian regiment made up entirely of natives is the finest lot of men in His Majesty's Service." It could hardly be expected that one who had never been to India would be in a position to differentiate between

the different races; so that the inclusion of the Bengali among the great fighting races of India is, therefore, quite easily understood. Nor would the point have called for any comment had it not been that the true facts afford still further evidence of the important rôle played by diet. The Bengali has never, so far as we are aware, in modern times been recruited for the fighting line, and, although many regiments were called Bengal Infantry, Bengal Cavalry, etc., not a single man carrying a rifle could claim Lower Bengal as his place of birth. We have no desire to labour the point, but the question arises: Why is the Bengali unfit for the fighting line when other inhabitants of the plains exposed to, and suffering from, practically all the disabilities that Dr. Kellogg enumerates—but on a superior diet—are capable of exhibiting the firmest courage and maintaining untarnished the great fighting traditions of their race? Thus we have the Sikhs, famous throughout the world for their endurance and fighting qualities, inhabitants of the hottest plains of India, yet men of splendid physique and full of energy; the Dogras, the Jats, Rajputs, all well-known for their own special qualities on the Indian frontier or wherever courage, determination and endurance are called for. These races labour under the disadvantages advanced by Dr. Kellogg to explain the relatively poor development of the average Bengali compared with Europeans or the warlike races abovementioned. Even in the various classes of these and allied races differences in physique, muscular vigour, hardiness and all those qualities that go to make up the perfect soldier can be detected. We believe and already have obtained a good deal of proof that diet, and particularly the level of nitrogenous metabolism attained, has an immense influence on the formation of these most desirable characteristics of the races whence is drawn our best fighting material. Further, although we have made no attempt to advance arguments for or against vegetarianism, it will be found that those races, whether of the hills or the plains, who are distinguished above all others for their manly qualities, are *never* vegetarians, but, on the contrary, usually large meat-eaters. The Sikh lives on wheat, vegetables and meat, particularly pork for which he has a special liking. The Rajput, Pathan, Baluchi, etc., are all meat-eaters, while the more or less purely vegetarian races—such as the Brahmins—are gradually undergoing elimination as recruiting sources for the Indian army. We shall say no more on this subject at present except to point out that the evidence bears out the results obtained by contrasting the Bengali and Behari. Further, that elimination of the several causes advanced by Dr. Kellogg from our comparison of tribes or races living under identical conditions as regards sexual excesses, climate, immature marriage, etc., brings out in its proper aspect the determining influence of diet on the character-formation of a people. Among those tribes where animal food is consumed as a regular part of the diet, the bolder and more adventurous spirit displayed by the individuals is very noticeable. Rousseau has no doubt about the matter. "It is certain," he

says, " that large meat-eaters are generally more cruel and ferocious than other men."

Experiments carried out by feeding one series of young monkeys on vegetable and another series on a highly animal diet confirm the same opinion—the meat-fed animals developing into much stronger and far more ferocious adults than those fed on vegetable material. As we have seen in the work on the nutritive value of the Bengal jail diets, the addition of meat in any form is a certain means of raising the level of nitrogenous metabolism. All the evidence we have hitherto been able to obtain points to a high level of protein interchange in the body being accompanied by a high development of physique and manly qualities, whilst under the opposite conditions, poor physique and a cringing, effeminate disposition alone can be expected.

In a sentence, we may conclude that manliness in a race is a function of its diet, and that as a rule " a low state of nutrition is accompanied by torpor or perversion of conscience; famine has not rarely brought rapine in its train." The truth of this conclusion appears from our work on the Behari and Bengali and is supported by the facts stated regarding the Sikhs, Rajputs, Dogras, Jats and Brahmins. However, as we have not yet made a detailed study of these tribes, at the present time we simply instance them to show that the factors that Dr. Kellogg lays stress on are insufficient to account for the low developmental conditions of the Bengalis, when contrasted with the Beharis or with any of the great fighting tribes of the plains of India.

We consider it probable that a thorough survey of the food customs of these Indian tribes, with careful observation of the effects on their respective development and character, will go a long way in helping to clear up many of the points at issue between the Chittenden school and those opposed thereto, and between vegetarians and those who believe in the advantages of an animal protein forming a fair proportion of the total nitrogen of the diet.

III. *Hill-tribes of Bengal.*—By far the best specimens of the hill-tribes of Bengal are to be found in Darjeeling district and its neighbourhood.

They may be divided into two great classes, each with two sub-classes :—

- I. Bhutias,
  1. Tibetan Bhutias and Nepalese Bhutias.
  2. Sikkim Bhutias or Lepchas.
- II. Nepalese,
  1. Chuttries—higher classes (Brahmins).
  2. Matwales (Mangar, Jinidar).

These tribes inhabit hills whose height is about 5,000 feet above sea-level. The climate is not so cold as that of England—misty and wet during most of the summer months; cold, bracing and clear in the winter. The contrast between

the Bengali and the inhabitants of these hills is exceedingly marked. They appear more like people of different parts of the universe rather than neighbours separated by barely 50 miles of country. Some of their more prominent characterist cs have already been alluded to, and strike the new-comer very forcibly. The men, women and children are jolly, light-hearted, always laughing, joking and chatting, the children playing, skipping, singing as they run about, very much in the way children do in England. This is all the very antithesis of what will be found in Bengal proper and Orissa. The children in Bengal are poor, miserable, pot-bellied little creatures with little or no joy in their lives compared with these happy-looking, well-fed children of the hills. The hill-people generally are healthy, strong and well-developed, some being of really fine physique; they are full of energy and capable of the most arduous and sustained muscular exertion.

The loads that even the women and half-grown children are capable of carrying up the steepest hills are incredible and, until seen with one's own eyes, would certainly not be believed possible.

So far as could be gathered, two factors account for the marked contrasts between the Bengali and these hill-tribes, *viz.*, climate and diet. The other factors mentioned by Dr. Kellogg are even more in evidence, particularly sexual excesses, than in Bengal. While we have no doubt climate has a great deal to do with the higher scale of general development and capabilities, that it is not the whole story can be shown by a comparison of the several classes living under practically identical conditions but with difference in dietary forming the one outstanding influence on their respective attributes. We can thus by a study of the different classes eliminate to a very great extent the effects of climate, and appraise at its proper value the influence of the different dietaries on the physique and general well-being of the mass of individuals forming the several tribes.

We shall take up the facts that we have been able to collect under the following headings :—

(1) Facts of physical development.
(2) Different diets of the several classes.
(3) Investigations on nutrition of prisoners in Darjeeling jail.
(4) Conclusions.

(1) *Physical development.*—As the number of prisoners in the Darjeeling jail was very limited—these tribes are usually very well-behaved, only rarely committing serious crimes—we had to make arrangements for collecting the required information outside the jail. This we were able to do in the bazaar, hospital, Bhutia villages, amongst coolie gangs, etc. The following summary gives the results obtained :—

Bhutias . . . 140 men examined.

(*a*) Tibetan Bhutias.

Height varies between 5 feet 6 inches and 5 feet 7 inches.

Tallest—5 feet 9 inches.

Shortest—5 feet.

Chest girth varies between 35 and 37 inches.

Greatest—38 inches.

Smallest—32 inches.

(*b*) Sikkim Bhutias commonly called Lepchas.

Height varies between 5 feet 4 inches and 5 feet 6 inches.

Tallest—5 feet 7 inches.

Shortest—5 feet.

Chest girth—the same as in the Tibetan Bhutias.

(Pure Lepchas are slightly smaller in stature than these.)

Nepalese . . . 64 men examined.

Height varies between 5 feet 2 inches and 5 feet 4 inches.

Tallest—5 feet 6 inches.

Shortest—4 feet 8 inches.

Chest girth varies between 32 and 34 inches.

Greatest—36 inches.

Smallest—30 inches.

Nepalese Bhutias are probably the finest specimens of manhood amongst the hill-tribes. They eat up to 2 lbs. of meat per day. Coolies drawn from this source have been found to give the greatest satisfaction in expeditions and explorations of the Himalayan ranges. Although the hill-men as a class are naturally healthy and hardy, the Bhutias as a general rule are stronger and better developed than the Nepalese—the Tibetan Bhutia being a particularly muscular hard-working individual; most of the hard work, such as carrying dandies, rickshaw work, etc., being done by them alone.

The women are equally well-developed and capable of the hardest work. Even the young girls think nothing of carrying the heaviest trunks or boxes up the very steep paths and roads in Darjeeling and its precincts.

It may be taken generally that the Bhutias do the greater part of the hard labour; the Nepalese are usually to be found working as ordinary coolies or as servants.

It will be observed from the statistics collected that the Nepalese are considerably smaller in stature than the Bhutias. They are also less hardy and less muscular.

The development of the neck and calf of the Bhutia is very marked for their height—an average of between 14 and 15 inches being obtained from the measurements.

The calf is well-developed also in the Nepalese, but on a somewhat lower scale than in the Bhutias.

The Bhutia from his earliest years is accustomed to the carrying of weights—and usually the heaviest weight that he can just stagger under ; as years go on and strength improves his capacity for weight-carrying gradually increases until in adult life weights of 200 lbs. and over are easily managed. A working cooly will go on carrying such burdens all day—making trip after trip in a way never seen in Bengal. The constancy of the Bhutia's working capacity is another noticeable feature when contrasted with the methods of the Bengal cooly, who, after even the slightest exertion, must have a rest and if possible a sleep.

Amongst the hill-tribes themselves the Nepalese and Tibetan Bhutias are the finest men in every respect, next come the Sikkim Bhutias and then the Nepalese.

Let us enquire what the dietaries of these tribes show.

(2) *The different diets of the several classes.*—In order to get the necessary information on this important point we enlisted the assistance of an Assistant Surgeon—Assistant Surgeon Swolle—who is himself a hill-man and has full knowledge of the language and customs of the different tribes. With his help we were able to obtain very precise information. The following list gives some idea of the dietaries of these people under their natural conditions :—

I.—Bhutias.

(*a*) Tibetan Bhutias, also Bhutias from Bhotan (dandywallas, coolies, etc., who perform the hardest work).

Rice	24 to 28 ozs.	Average value of the diet computed to be worth 28 grms. nitrogen or 175 grms. protein, of which well over 60 per cent. is derived from an animal source.
Meat (beef generally or mutton)	16 to 20 ozs.	
Vegetables (potato, cabbage, carrots, etc.	6 to 10 ozs.	
Butter	4 ozs.	
Bread	6 to 8 ozs.	
Cheese	2 ozs.	
Alcoholic liquor, a home product called murwa	2 pints	
or		
Tea prepared with 1 oz. of tea, butter and soda	Q. S.	

(*b*) Diet of Tibetan Lamas (priests and those who have not such hard work as the dandywallas, etc.).

Rice	18 to 22 ozs.	Average value computed to be 25·6 grms. of nitrogen or 160 grms. of protein of which over 60 per cent. is derived from a animal source.
Meat	14 to 18 ozs.	
Vegetables as before	6 to 8 ozs.	
Chutto (a food prepared from pulse)	8 ozs.	
Alcoholic liquor	1—2 pints	

(*c*) General diet of the more poorly-fed classes who earn lower wages.

Rice	16 to 18 ozs.	Average value computed to be 24 grms. of nitrogen or 150 grms. protein of which over 70 per cent. is derived from an animal source.
Meat	16 ozs.	
Vegetables	8 ozs.	
Cheese	2 ozs.	
Alcoholic liquor	2 pints	

(*d*) Diet of Sikkim Bhutias (hard working classes).

Rice	16 ozs.	Average value of the diet computed to be worth 21 grms. nitrogen or 131 grms. protein of which over 70 per cent. is derived from an animal source.
Meat	16 ozs.	
Vegetables, wine, etc.	as before	
Dal	2 ozs.	

(*e*) Diet of Lepchas (poorer classes of Sikkim Bhutias).

Rice	28 to 30 ozs.	Average value of the diet 18·5 grms. of nitrogen or 115 grms. protein of which about 50 per cent. is derived from an animal source.
Meat	8 to 10 ozs.	
Other items same as before.		

II.—Nepalese.

(*a*) Matwali of the higher classes—Chuttries.

Rice	16 ozs.	Average value of the diet 19·2 grms. or 120 grms. protein of which less than 40 per cent. is derived from an animal source.
Dal	4 ozs.	
Meat (never beef)	8 ozs.	
Vegetables, etc.	8 ozs.	
Alcoholic liquor	1—2 pints	

(*b*) Nepalese matwali (cultivators, coolies of poorer classes).

Rice	24 to 28 ozs.	Average value of the diet 17·5 grms. nitrogen or 110 grms. of protein of which only a small percentage is derived from an animal source.
Dal	4 to 6 ozs.	
Meat (when it can be afforded, usually once a week)	8 ozs.	
Vegetables and alcoholic liquor	as before	

All drink tea and alcoholic liquor; sometimes maize replaces part of the rice, and bread is taken when it can be afforded.

These figures only give the averages and are probably rather below than above the mark. They are quite sufficient to show how very superior the dietaries of these hill-tribes are compared with those in use in Bengal. The list discloses remarkable results; it may be taken that the average protein value of the dietaries of the Bhutias is about 160 grms. and of the Nepalese 115 grms. The most important point, however, is not the large amount of protein but the manner in which the total protein is made up. We have shown in detail how poor the protein absorption is from a diet consisting of rice and dal, and how marked an influence the addition of an animal protein exerts in raising the level of absorption.

Here we have in vogue amongst the Bhutias dietaries in which over 60 per cent. of the nitrogen is derived from an animal source; even accepting that the whole of the rice of their diet was consumed, this in itself would mean that the level of protein metabolism amongst them is relatively very high. Further, the constant hard work of their daily round calls for a very large expenditure of energy, so that the digestion of rice and other carbonaceous ingredients of the diet is also placed on a higher level than is found in the Bengali; we may take it, therefore, that at least 75 per cent. of this diet is absorbed under natural conditions. (This is in all probability too low an estimate, but it may be allowed to stand as it errs on the right side.) That is, the Bhutia shows a nitrogenous metabolism of about 19·2 grms. per day, or per kilo of body-weight 0·35 grm. of nitrogen. The average weight of the Tibetan or Nepalese Bhutia is, over the numbers weighed, 60 kilos or 128 to 132 lbs.[1] We see, therefore, that the level of nitrogenous metabolism is practically three times that laid down by Chittenden, and twice that of the standard to which we hope to raise Bengal prisoners.

By the same method of calculation the nitrogenous metabolism of the Nepalese and poorer classes of the Sikkim Bhutias would work out at an average of about 13 grms. or the metabolism of 0·25 grm. of nitrogen per kilo of body-weight; whilst that for the Nepalese cultivator and poorer classes of Nepalese is lower still, due to the absence of meat except on one or two days a week. We, therefore, find that the dietaries show a gradual decline in the amount of nitrogen per kilo of body-weight undergoing metabolism, and, in accordance with this observation, it will be evident there is an accompanying gradual fall in the physique and general developmental conditions of the different tribes from Nepalese and Tibetan Bhutia to Sikkim Bhutia, and lastly to the lower classes of the Nepalese. This can only be explained on the basis of differences of diet: for the other factors put forward by Dr. Kellogg are common to all the tribes and particularly to the individuals examined in and around Darjeeling. To anyone who has seen the strong, muscular dandywalla and the altogether slighter though compactly built Nepalese no evidence will be required to bring out the superior physical development of the former; and when along with this we find the Bhutia reaching a level of protein metabolism much higher than the Nepalese, the conclusion that a close relationship exists between the scale of protein metabolism and muscularity is justifiable.

The evidence, therefore, afforded by investigations on the dietaries and general development of these tribes corroborates the conclusions already arrived at from a comparison of the Bengali, Behari and—incidently—the great fighting tribes of the Punjab, *viz.*, that physical development, other things being equal,

[1] With the assistance of the District Superintendent of Police in Darjeeling—Mr. Bradley—Captain Hamilton, I.M.S., was able to obtain the weighments of 100 dandywallas [Tibetan or Nepalese Bhutias]. The average weight was practically 60 kilos.

is a function of the protein metabolism possible from the diet. It is worthy of note that there is very little dysentery, diarrhœa or bowel complaint present amongst the individuals of these tribes. The stools are well-formed and regular, and very much a contrast to the semi-fluid excretion of the Bengali.

We made some observations on the blood of the Bhutias and Nepalese in Darjeeling jail, but no difference of impoıtance could be detected. Thus the average of 28 observations gave :—

	Bhutea.	Nepalese.
Hæmoglobin	84%	84%
Red b. Corps	5,360,000	5,280,000
White b. Corps	9,740	9,660

As these prisoners get the same diet while under confinement in all probability any racial differences in the composition of the blood would have disappeared. It was found impossible to get blood from these outside the walls of the jail, so that differences may exist.

(3) *Investigation on the nutrition of prisoners in Darjeeling jail :*

TABLE XXVI.

(*a*) In order to obtain some idea of what the level of nitrogenous metabolism of Bhutias and Nepalese would be on a diet more or less similar to their accustomed diet, we placed a mixed batch of six prisoners on the following :—

Rice	120 ozs.=20 ozs. per man.
Dal	24 ozs.= 4 ozs. ,,
Meat	96 ozs.=16 ozs. ,,
Vegetables	36 ozs.= 6 ozs. ,,

Observed for nine consecutive days.

Batch.	Quantity of Urine.	Total N. of Urine.	N. of Rice.	N. of Dal.	N. of Meat.	N. of Vegetables.	Weight.
	c. c.	grms.	grms.	grms.	grms.	grms.	lbs.
Mixed Bhutia and Nepalese prisoners.	9,110	89·62	37·44	25·05	65·30	2·83	123·6
	11,110	89·70	37·44	25·05	65·30	2·83	..
	11,620	88·30	37·44	25·05	65·30	2·83	..
	11,900	91·29	37·44	25·05	65·30	2·83	123·6
	11,300	89·68	37·44	25·05	65·30	2·83	..
	9,000	91·98	37·44	25·05	65·30	2·83	..
	13,380	95·81	37·44	25·05	65·30	2·83	123·5
	11,760	97·63	37·44	25·05	65·30	2·83	..
	12,000	101·80	37·44	25·05	65·30	2·83	123·6

Total intake of nitrogen=1175·58 grms.

Total output
N. of Urine . . . =835·81 grms.
0·5 grm. daily constant . =27·00 ,,

Total nitrogenous metabolism . =862·81 ,,
=73·90 per cent. of the nitrogen of the diet
or 15·98 grms. of nitrogen per man daily.

We, therefore, see that a fairly high percentage of the total nitrogen of the diet is absorbed even though it does contain a large amount of rice. The metabolism of practically 16 grms. of protein per man daily is very much greater than anything we found in the Bengali or Behari, and makes very evident the superior type of diet that these tribes live on. For these six prisoners the nitrogenous metabolism works out to be 0·284 grm. per kilo of body-weight, over two and a half times the quantity stated by Chittenden to be more than sufficient to meet the nitrogenous requirements of the body; yet this diet is not by any means so high in protein as that to which the well-paid and superior classes of the Nepalese and Tibetan Bhutias are accustomed. This diet is worth in round numbers about 140 grms. of protein, whereas the dietaries of the Tibetan Bhutias may be taken to have an average value of 160 grms., with a maximum approaching closely 200 to 220 grms. per man daily.

(*b*) In order to determine the degree of nitrogenous metabolism attained by Bhutias and Nepalese on the ordinary jail diet we placed a mixed batch of six prisoners on the diet in use in Darjeeling jail.

This diet appears to vary in the quantities of the different ingredients from day to day, but it is made up of . . . . Rice, makkai ata, (porridge) dal and vegetables.

Six prisoners observed over ten consecutive days.

Batch.	Total quantity of Urine.	Total N. of Urine.	N. of Rice.	N. of Makkai ata.	N. of Arhar dal.	N. of Vegetables.	Weight.
	c. c.	grms.	grms.	grms.	grms.	grms.	lbs.
Six prisoners in Darjeeling jail.	9,370	48·53	20·59	42·33	35·64	2·83	125·3
	9,760	52·60	20·59	42·33	35·64	2·83	..
	9,710	53·55	28·08	31·75	35·64	2·83	..
	11,210	47·08	20·59	42·33	35·64	2·83	..
	10,500	46·45	20·59	36·82	35·64	2·83	..
	11,940	47·48	34·49	..	35·64	2·83	..
	10,400	45·84	48·67	..	35·64	2·83	..
	11,890	48·93	20·59	31·31	35·64	2·83	..
	9,520	50·37	20·59	42·33	35·64	2·83	..
	12,470	51·85	28·08	18·52	35·64	2·83	125·4

This diet works out to be on an average over the ten days :—

Rice	14 ozs.	per man daily.
Makkai ata	11 „	
Dal	6 „	
Vegetables	6 „	

Total intake of nitrogen=935·28 grms.

Total output

N. of Urine	492·68 grms.
0·5 grm. daily constant	30·00 „
Total nitrogenus metabolism	522·68 „

=55·88 per cent. of the nitrogen of the diet
=8·71 grms. of nitrogen per man daily.

From this we learn that hill-men, when placed on a diet very similar to the makkai ata diet of the Behari, give practically identical results as regards the amount of protein undergoing metabolism.

This investigation further brings out the fact that the jail dietary is very inferior to the ordinary scale to which these tribes are accustomed in their own homes. This jail would, therefore, appear to be the only one in Bengal where the prisoners are not better fed inside the jail than outside. The difference is very marked as regards the protein metabolism; in round numbers we found it to correspond to 16 grms. of nitrogen per man daily, whereas the jail diet only provides for a metabolism of about 9 grms. of nitrogen per man daily. From the standpoint of a well-fed Bhutia the jail food would be considered absolutely penal. This may have something to say to the very small number of Bhutias to be found in prison.

(c) In order to determine whether the nitrogenous metabolism of Bhutias and Nepalese would be similar to that of Beharis on a wheat ata diet we placed a mixed batch of Bhutias and Nepalese on the diet from which was obtained the maximum absorption in Bhagalpur jail. This was :—

Rice	12 ozs.	per man daily.
Wheat ata	10 „	
Arhar dal	6 „	
Vegetables	6 „	

Twelve Bhutia and Nepalese prisoners observed for five consecutive days.

Batch.	Total quantity of Urine.	Total N. of Urine.	N. of Rice.	N. of Wheat ata.	N. of Athur dal.	N. of Vegetables.	Weight.
	c.c.	grms.	grms.	grms.	grms.	grms.	lbs
Twelve prisoners in Darjeeling jail.	12,930	128·32	44·94	67·38	71·56	5·46	122·0
	15,600	121·48	44·94	67·38	71·56	5·46	122·1
	17,520	122·31	44·94	67·38	71·56	5·46	122·0
	17,150	116·32	44·94	67·38	71·56	5·46	122·0
	16,660	123·93	44·94	67·38	71·56	5·46	122·1

Total intake of nitrogen=947·70 grms. Total output—

N. of Urine . . . . 612·39 grms.
0·5 grm. per man daily constant 30·00 „

Total N. metabolism . . . 672·39 „
=70·90 per cent. of the N. of the diet
=10·70 grms. of nitrogen per man daily.

We again learn that these hill-men give practically identical results with the Behari prisoners in Bhagalpur jail when the two classes were placed on similar diets. It is, therefore, evident that the protein absorption from a diet depends entirely on the way in which it is made up, and not on the greater or less absorptive power of one individual or race compared with another individual or race. This finding we have plenty of evidence to prove and have already referred to it in previous parts of this work.

A comparison of the level of nitrogen metabolism attained by Bhutias and Nepalese, when placed on the most efficient Behari dietary, with their nitrogenous metabolism when on a diet only approximately as nutritious as that to which they are accustomed, again serves to bring out clearly the great superiority of the dietaries of these hill-tribes.

From the evidence adduced there would appear to be no doubt that the splendid physical development seen amongst these men is due very largely to the highly nutritious food materials on which they live, under the natural conditions available in the earlier years of life when growth is taking place.

(4) *Conclusions arrived at regarding the relationship of food to physical development.*—We have shown that it is quite possible for an individual to subsist on the amount of protein stated by Chittenden to be sufficient; in fact, there can be little doubt but that the teeming millions of Bengal have an even lower level of

nitrogenous metabolism than Chittenden's standard. So far, our work corroborates his results. But when we look at the other side of the question and make an attempt to estimate what the effects of dietaries, providing so low a standard of nitrogen absorption, are on the physical well-being of the people we are forced by the evidence to attach much greater importance to the glaring ill-effects of such diets than to their physiological economy or the supposed advantages of a low protein intake to the excretory system.

From a study of the urine, blood, physical development and general capabilities of the Bengali we expressed the conviction that the diet on which he subsists was largely to blame for his miserably poor physique and want of vigour. Nothing we have learned in this further study has tended to contravert that opinion; on the contrary, the more the subject has been gone into the stronger the evidence becomes of its correctness. It is admitted by everyone that, compared with the working European, the Bengali labourer is on a very low scale; vegetarians and the followers of Chittenden have assigned every possible cause that could be thought of, *except diet*, as offering a full and complete explanation of the Bengali's inferior capabilities. We have discussed these hazy, ill-defined influences and, whilst admitting the probable force of some of them, have largely eliminated them by contrasting individuals, tribes or races in which all these factors are identical, but in which diet alone forms the distinguishing element, or—to put it more correctly—in which the level of protein metabolism forms the great line of demarcation.

From this point of view we contrasted the Bengali, Behari and some of the great fighting races of the Punjab—all inhabitants of the plains, of the same or closely allied religious beliefs, and customs regarding marriage, and under climatic conditions that are practically identical; the evidence of the rightful position of these races in the category of men, and their respective claims to manly qualities force us to the same conclusion, that diet or absorbable protein is the all-important element in the development and character-formation of a people.

From a study of the hill-tribes around Darjeeling we have been able to gather most important information bearing on this question; and again, it becomes evident that the well-developed and more muscular races are those whose diet is very superior in the amount of absorbable protein it presents. We need not go into details of the work carried out on these tribes. The main fact, so far as we are at present concerned, is that the Bhutia, by far the most capable of these people in those occupations requiring great muscular exertion, attains a nitrogenous metabolism much higher than any other tribe, or, indeed, any other race that we have investigated. Just as was the case with the inhabitants of the plains, so we find with the races in the hills—variations in the amount of nitrogenous metabolism

appear to be the determining factors of the several causes that go to relegate, fix and maintain the position of a people, tribe or race in the scale of mankind. Of all the different races that we have investigated the scale of the relative development, vigour and general muscularity is easily fixed. The following may be taken as showing how the several tribes would be placed, together with the several degrees of nitrogenous metabolism per kilo of body-weight to which they attain :—

	N. per kilo of body-weight.
(*i*) Bhutias—	
Nepalese Bhutias	. 0·42 grm. (very highly animal diet).
Tibetan and Bhotan . . .	. 0·35 ,,
Sikkim Bhutias	. 0·25 ,,
(*ii*) Nepalese	. 0·18 to 0·25 grm.
(*iii*) Beharis	. 0·145 grm.
Prisoners	. 0·173 grm.
(*iv*) Bengalis and Ooriyas . . .	. 0·116 grm.
Prisoners	. 0·151 grm.

The close relationship between the nutritive value of the several dietaries and its influence on the physical development of the different peoples of Bengal is clearly brought out by this list with its accompanying scale of nitrogenous metabolism.

The aboriginal tribes of Chota Nagpur.—We shall conclude, and complete the work done in Bengal, by a short summary of the information supplied us with regard to the aboriginal tribes inhabiting the Ranchi plateau.

Major Maddox, I.M.S., Civil Surgeon, Ranchi, kindly collected this information for which we are most grateful.

In Part I, Chapter II, Section (2) (*e*), will be found an account of the experimental work carried out on representatives of four of the principal tribes, *viz.*, Pater, Moonda, Swansi and Uraon.

We found on the whole that the level of nitrogenous metabolism was distinctly on a higher scale with these men than was the case with Bengalis and Ooriyas on a similar diet. What the true explanation of this is we are not in a position to state.

If we had obtained similar results with the Darjeeling tribes it might have been justifiable to assume that people inhabiting the hills, and accustomed to a better diet than inhabitants of the plains, were able to absorb a higher percentage of the protein from an identical diet. But, while the Darjeeling tribes did show a slightly better protein absorption than Beharis on the same diets, the difference is too small to be any proof that such an assumption is absolutely right.

The characteristics on which we laid such stress when discussing the Darjeeling hill-tribes are also to be found amongst these aborigines. While of no great size,

the average aborigine is a most capable worker, bright, cheery and alive to his surroundings. In muscular development he is very superior to the Bengali, but, as would be expected from his diet, inferior to most of the Bhutias and Nepalese. His physical development and general capabilities would again confirm the conclusions already arrived at from a study of the Bengali, Behari and Bhutia, *viz.*, that the position of a tribe or race in the scale of physical development is largely a matter of the amount of absorbable protein offered in the dietaries.

The differences in the natural dietaries of these four tribes are not sufficiently well marked to show any real distinction in physical development. We append the notes which Major Maddox was able to obtain.

Patora or Paters.

These people were originally Mundas, but have now become completely Hinduized.

The Patora, or Pator Mundas as they are often called, are only found in what used to be the Rahey thana circle, this part now being divided up between the Sonahatu and Silli thanas. Closely related to them, and practically similar in all respects, are the Kangar Mundas found round Ranchi itself and Khunti.

It is not known how long ago these people became Hinduized, but there seems to be no doubt of their origin.

Though they speak Hindi and Bengali to some extent, their language among themselves is Mundari.

They eat the flesh of fowls and goats, but never eat cow or buffalo or pig.

They consider themselves higher than Mundas, Uraons, Sawansis or Lohars, and do not intermarry with or eat with them.

The original work of the caste seems to have been oil-making and selling, but now they also do some cultivation.

The general physique of these people is better than that of the Mundas so far as can be seen.

Average height and weight of 100 Pater prisoners.	Food at home, daily quantity and animal food taken.
Height — 5'-3⅛" . . . . . . Weight — 104 lbs.	Daily consume about 22 ozs. of rice, 4 ozs. dal. Generally drink Hari (a form of wine) every night before supper. Also take fish, meat, mutton, milk and fowl.

Mundas.

These people, classed by Colonel Dalton as Kolarians, appear not to be connected with the Dravidian races, and to have entered India originally from the North-East.

It is believed that at one time they peopled the whole of Northern India, but they never seem to have gone to the southern part of the Peninsula.

They have also been identified with a black race who for a long time peopled the southern part of China, and was finally driven out by the Chinese after many years of extremely bloody warfare.

They can also be traced by some physical peculiarities and by certain rules of their language to be connected with some of the aborigines of Australia and the South Sea Islands.

I am informed by the Revd. Father Hoffmann, S. J., that there are more than one hundred words in Mundari which are pure Chinese. Among these are several of the numerals.

In more recent times, comparatively, they were found in Behar, and it is believed that on wandering thence they at last found themselves on the Chota Nagpur plateau, where they seem to have been the first settlers. It is difficult to say how long they have been settled on the plateau, but probably they came hither before the Christian era. They now chiefly occupy the southern and south-eastern portions of the district of Ranchi.

In physique they are short, and their skins are darker in colour than that of any other people on the plateau. As children they may occasionally have some pretensions to good looks, but these are practically never present in adult life in either sex.

Their diet is universal and they eat all kinds of flesh including that of rats and snakes. They also eat certain insects.

Their cattle are all used for ploughing. Consequently the cows are seldom milked and it is probably only at the seasons when little or no ploughing is being carried on that cow's milk is used to any extent as a food. In fact, if a woman dies leaving a small infant it is only in a very small percentage of cases that the child has any chance of surviving.

Average height and weight of 100 Munda prisoners.	Food at home, daily quantity and kind of animal food taken.
Height — 5′-3¼″ Weight — 107¾ lbs.	Rice and dal in both the meals. Quantity same as Pater. Also take fish, milk, meat, mutton, beef, pork and buffalo.

Sawansis.

These people are Mundas Hinduized at a remote period.

They are the weavers of Chota Nagpur, being found in nearly every village, where they live among the other people carrying on their work as weavers of the coarse country cloth worn by the poorer classes.

As they seldom own any land they are dependent on the villagers, who bring them the cotton grown by themselves. They consider themselves to be Hindus and will not eat or intermarry with Mundas or Pators. They do not eat the flesh of cows, buffaloes or pig, but goats' flesh is their staple diet, and, as it is difficult for them to keep goats as they have little or no land of their own, they have developed into a caste of professional thieves, the principal thing stolen by them being goats which they promptly eat.

The Revd. Father Hoffmann, S.J., from whom my information about these people is derived, tells me that they live on goats' flesh which is nearly all of it stolen.

Average height and weight of 100 Sawansis.	Food taken by them.
Height -5-3" . . . . . . Weight — 100 lbs.	Rice and dal in both the meals. Quantity and time of food same as Pator and Munda. They also take fish, meat, mutton, and fowls.

Uraons or Oraons or Khurunkh.

These people are classed by Colonel Dalton as Dravidians and he states that they are related to the peoples of the South of India, and that their languages are closely related. He considers that they came into India from the North-West at the same time as, or at a later date than, the Kolas from whom the Mundas have their origin.

These people, like the Mundas, are said to have been at one time in Behar and then having wandered westwards to have returned and for some time to have settled around about Rohtas, or possibly that they came from the west about Gujrat in which they had settled. When driven thence some are said to have gone to the Rajmahal hills, and the rest to the Chota Nagpur plateau to form the race now occupying part of the plateau and known as Oraons or Khurunkhs. This is believed to have occurred about the time of the Christian era or at a later date than the Mundas' migration.

These people occupy a portion of the Ranchi District extending from near Ranchi town westwards and north-westwards.

In physique they are distinctly finer than the Mundas and, at any rate in the earlier years of life, many of both sexes have some pretensions to good looks. As they grow older they degenerate rapidly, and the forward projection of the upper jaw and teeth which is a distinctive character of these people becomes much more noticeable and disfiguring.

In intelligence they are above the Mundas. Many who have emigrated to the tea-gardens become remarkably intelligent and raise themselves considerably above their original level of social life and comforts.

Their diet in their native conditions is practically anything that they can catch including jackals, snakes, lizards and insects. At their feasts they consume large quantities of buffalo meat. They always eat meat when they can get it and are specially fond of pork. They are clean in their persons and fond of personal adornment with beads, coins and necklaces made of grass and seeds and other things. The females are all tattooed in childhood with three—usually vertical—marks on the forehead a little above the root of the nose. Although their cows are used in ploughing, milk is made more use of as an article of food by them than by the Mundas.

It is rare for any aboriginal people to cook food more than once a day. The rice is cooked in the evening in sufficiently large quantity to provide for two meals, one portion is eaten with hot vegetables, meat and condiments at night, and the remainder is kept and eaten cold, frequently only with salt, at any time from about 8 A.M. to noon.

Average height and weight of 100 Uraon prisoners.		Daily food, etc.
Height	—5′ 3¾″	Rice and dal at both meals. Take marua bread as morning meal, in the season of the year (August and September). Quantity same as Pater, Munda and Sawansi. Animal food same as Munda or in larger quantities.
Weight	— 107½ lbs.	

This concludes the work that we have been able to perform on Bengal jail dietaries and on the different problems that have cropped up during the course of our enquiry. One of the most interesting questions is undoubtedly the relationship of the degree of nitrogenous metabolism to physical development and the general characteristics of the people of a race. We have brought a good deal of evidence forward to show that an intimate connection does exist, and that diet is a powerful factor in determining the position of a tribe or race in the scale of mankind.

This line of research we hope further to elaborate from a study of the great fighting races of the Punjab and Rajputana ; at present we know enough to say that a diet of rice and dal does not appear to conduce to the formation of the special characteristics that are desirable in those recruited for the fighting line, nor to the muscular development essential for the performance of a hard day's work. On the other hand, in those races where an assimilable protein, and particularly an animal protein forms part of the ordinary diet, muscular development and good fighting qualities seem to be intimately related with the level of nitrogenous metabolism attained.

CHART I.

CHART OF PROTEIN METABOLISM FROM DIETARIES

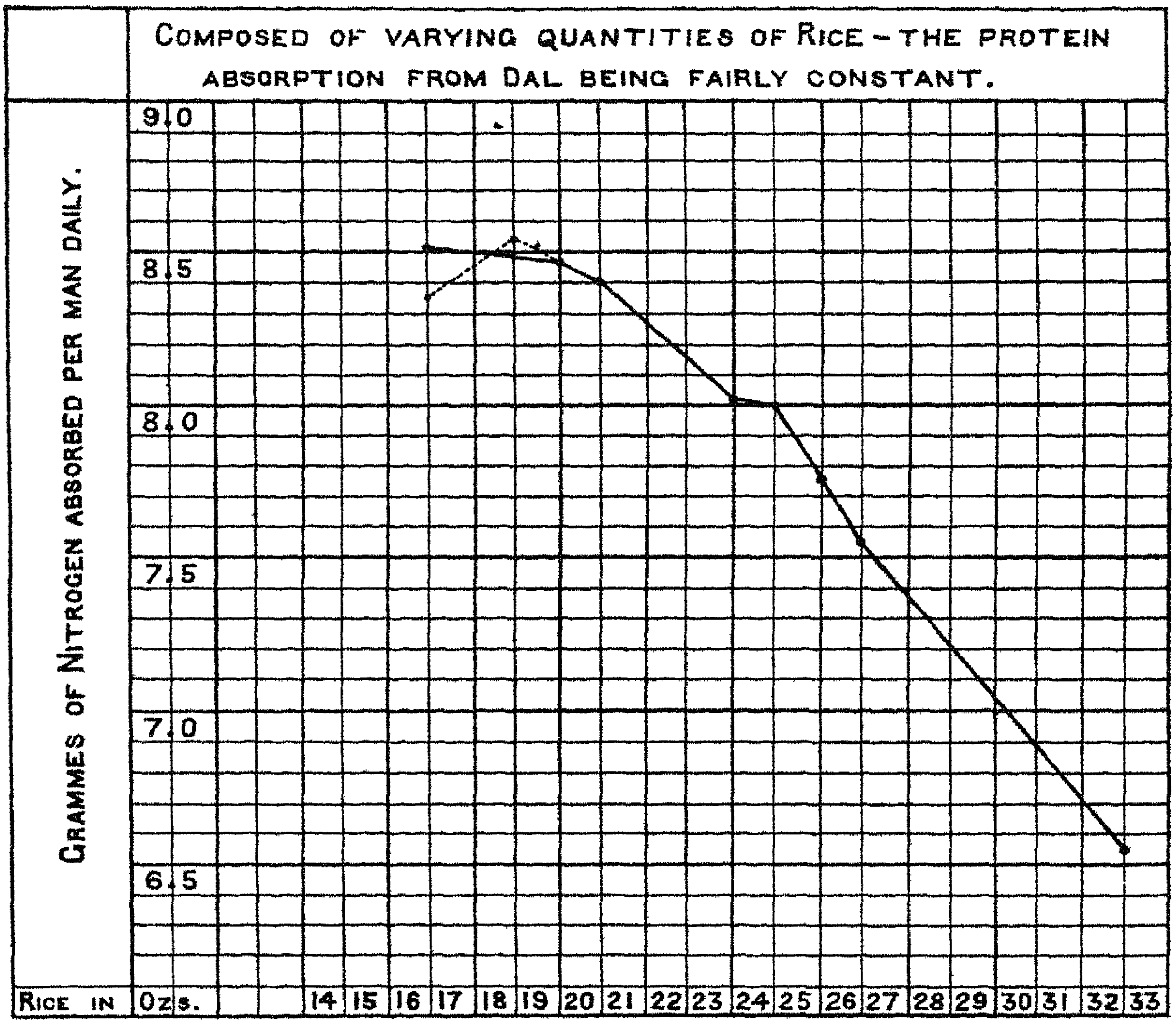

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CHART II.

CHART OF PROTEIN METABOLISM FROM DIETARIES

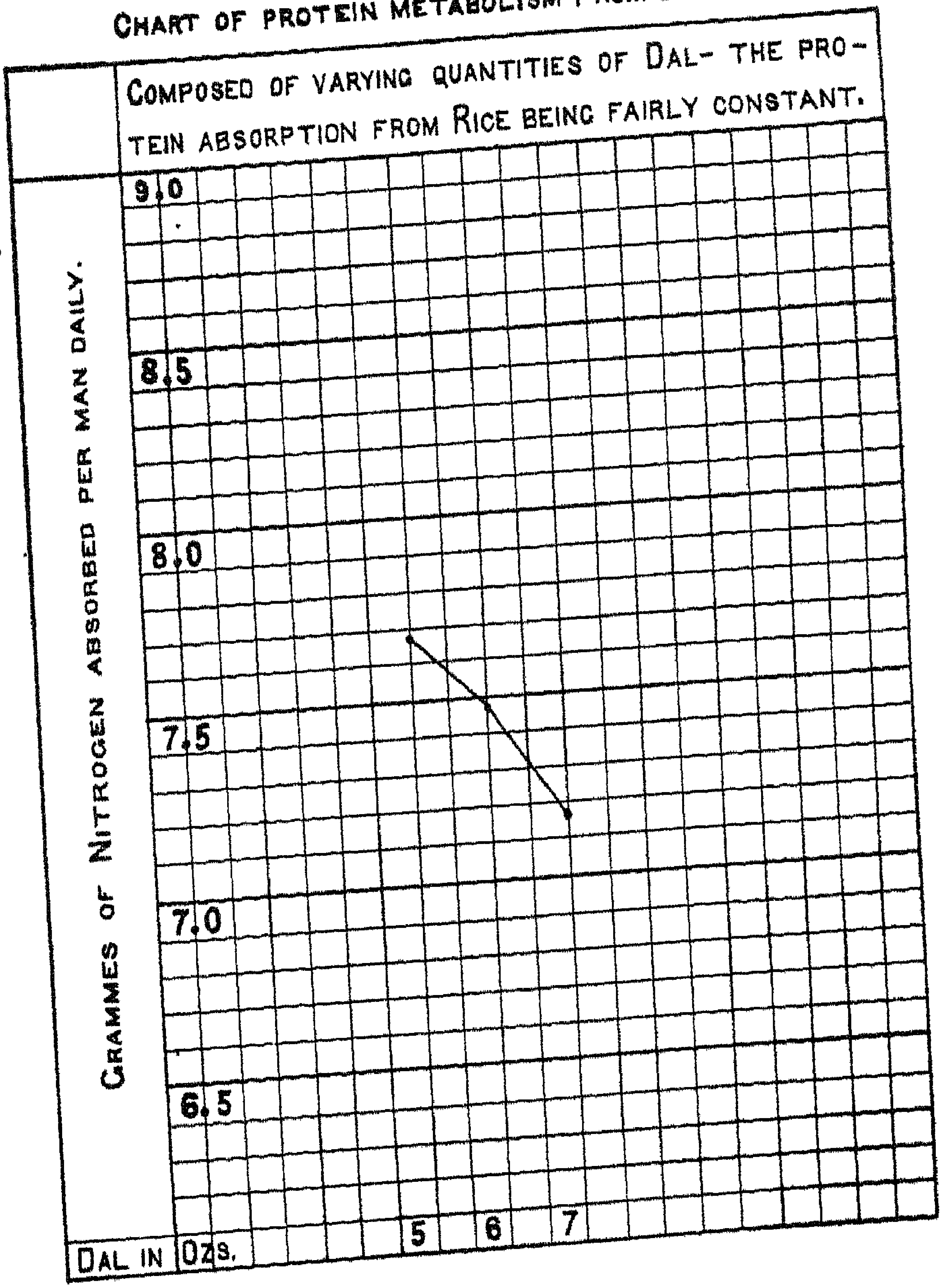


CHART III.

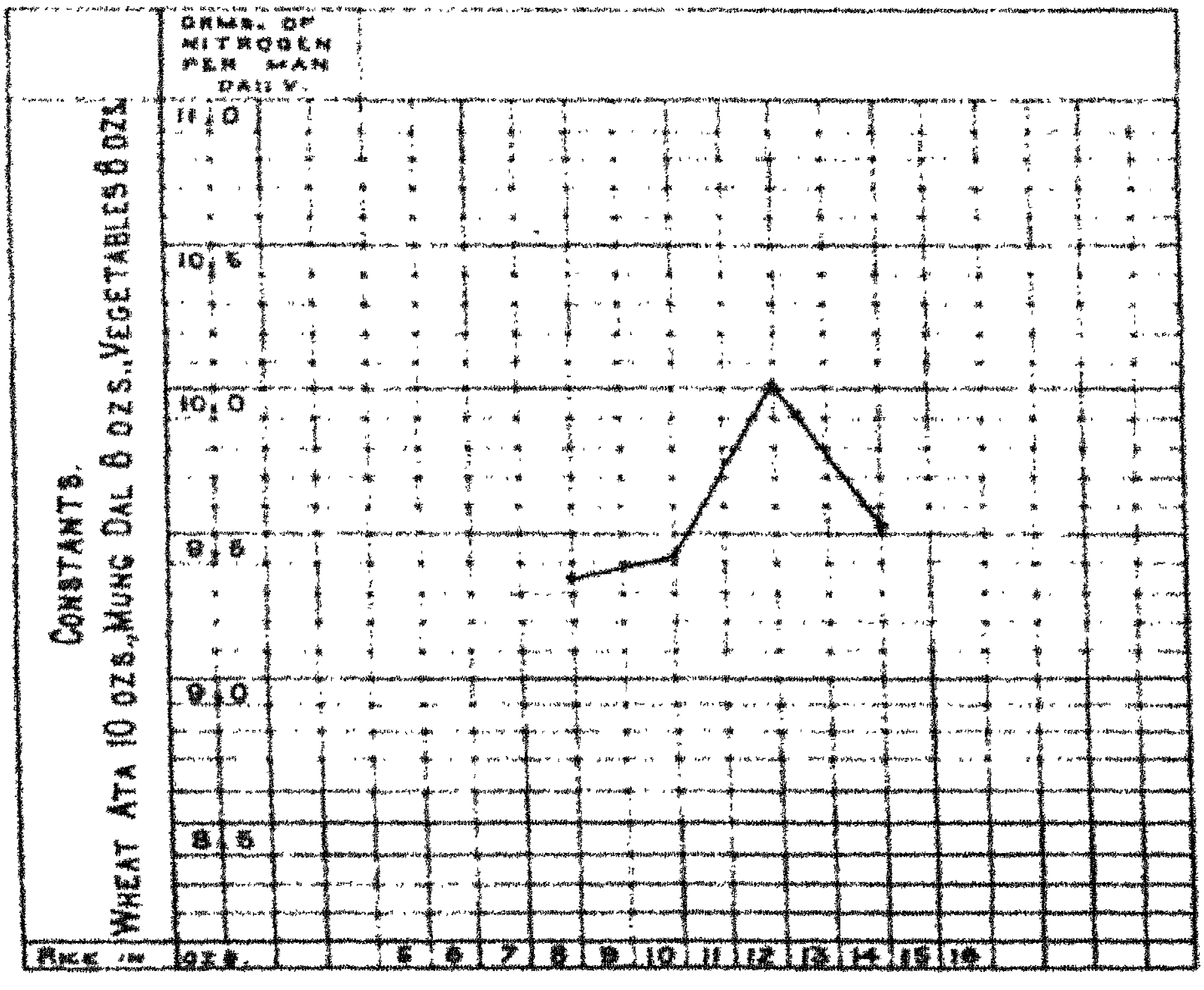

GRMS. OF NITROGEN PER MAN DAILY.
11.0
10.5
10.0
9.5
9.0
8.5
CONSTANTS.
WHEAT ATA 10 OZS., MUNG DAL 8 OZS., VEGETABLES 8 OZS.
RICE IN OZS.
5 6 7 8 9 10 11 12 13 14 15 16

CHART IV.

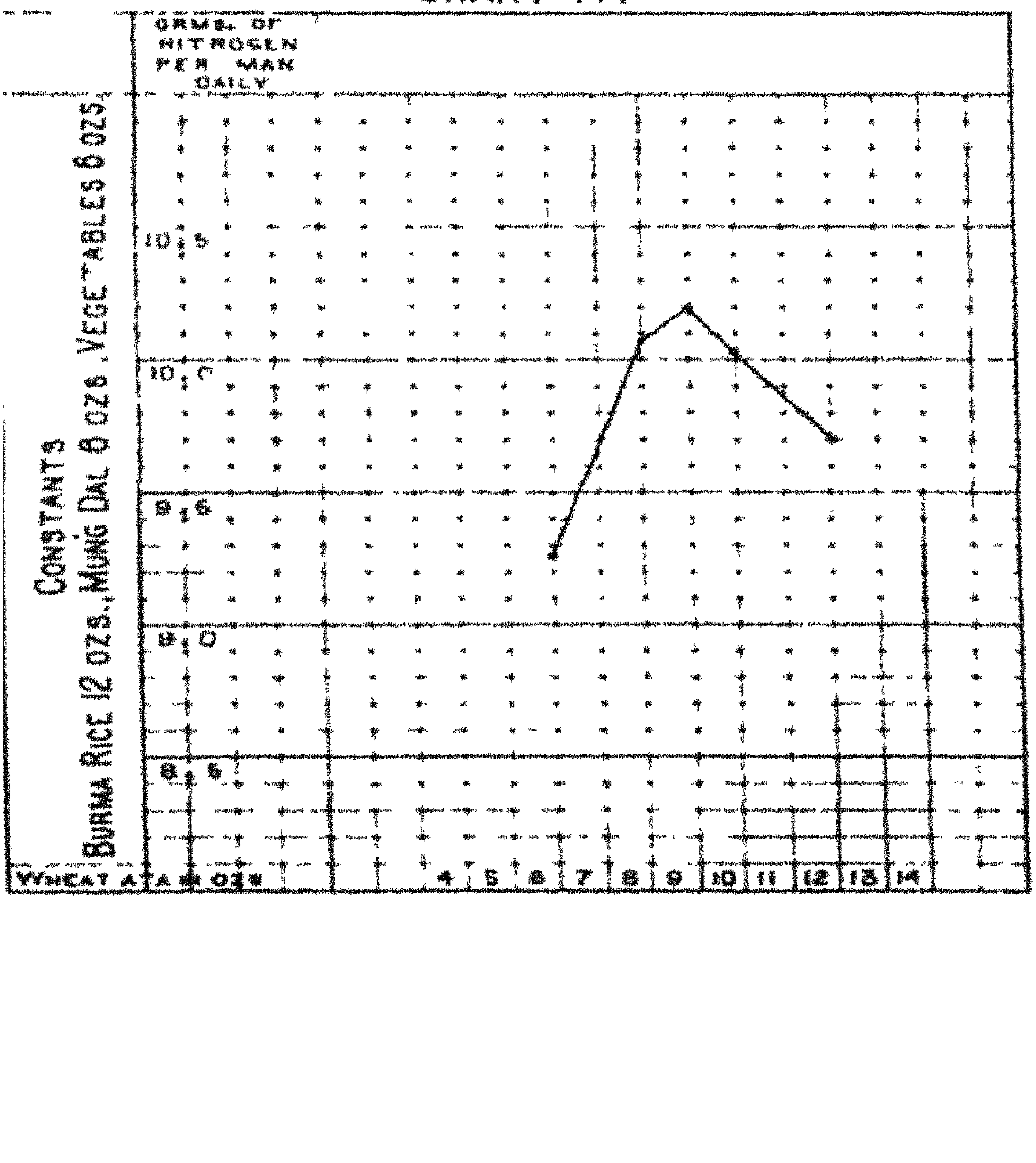
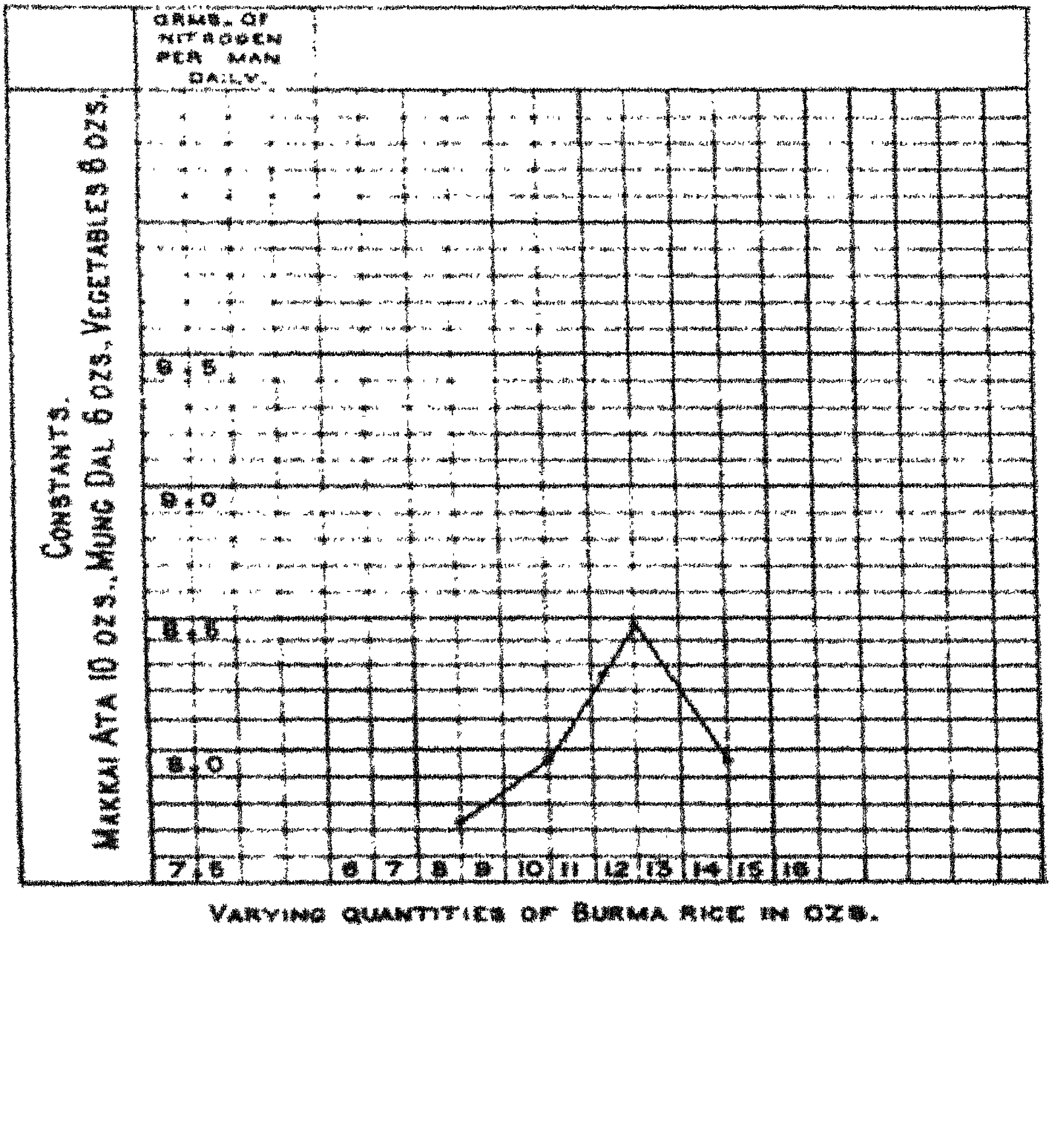
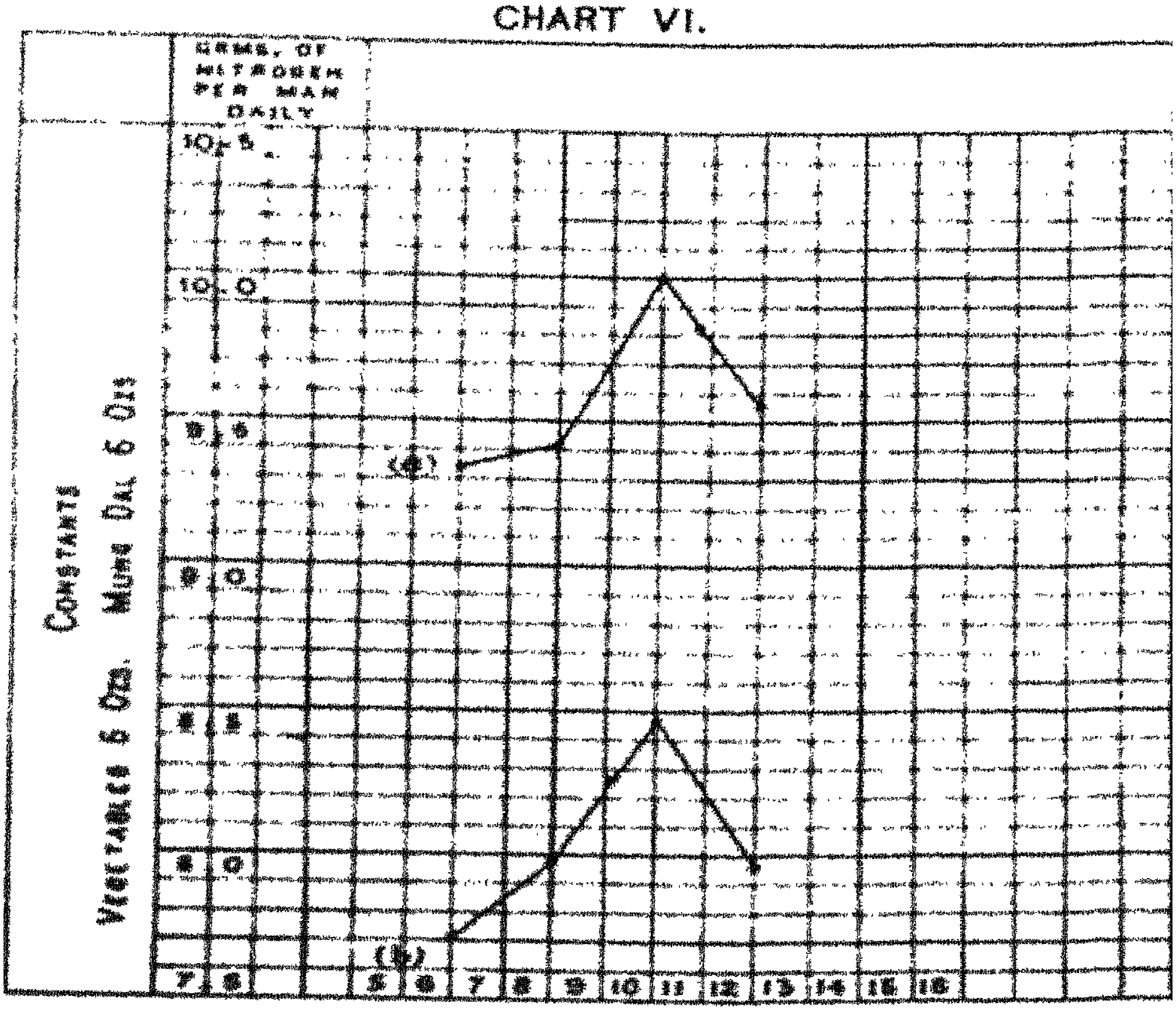

GRMS. OF NITROGEN PER MAN DAILY
10,5
10,0
9,5
9,0
8,5
CONSTANTS
BURMA RICE 12 OZS., MUNG DAL 6 OZS., VEGETABLES 6 OZS.
WHEAT ATA IN OZS
4
5
6
7
8
9
10
11
12
13
14

CHART V.



VARYING QUANTITIES OF BURMA RICE IN OZS.

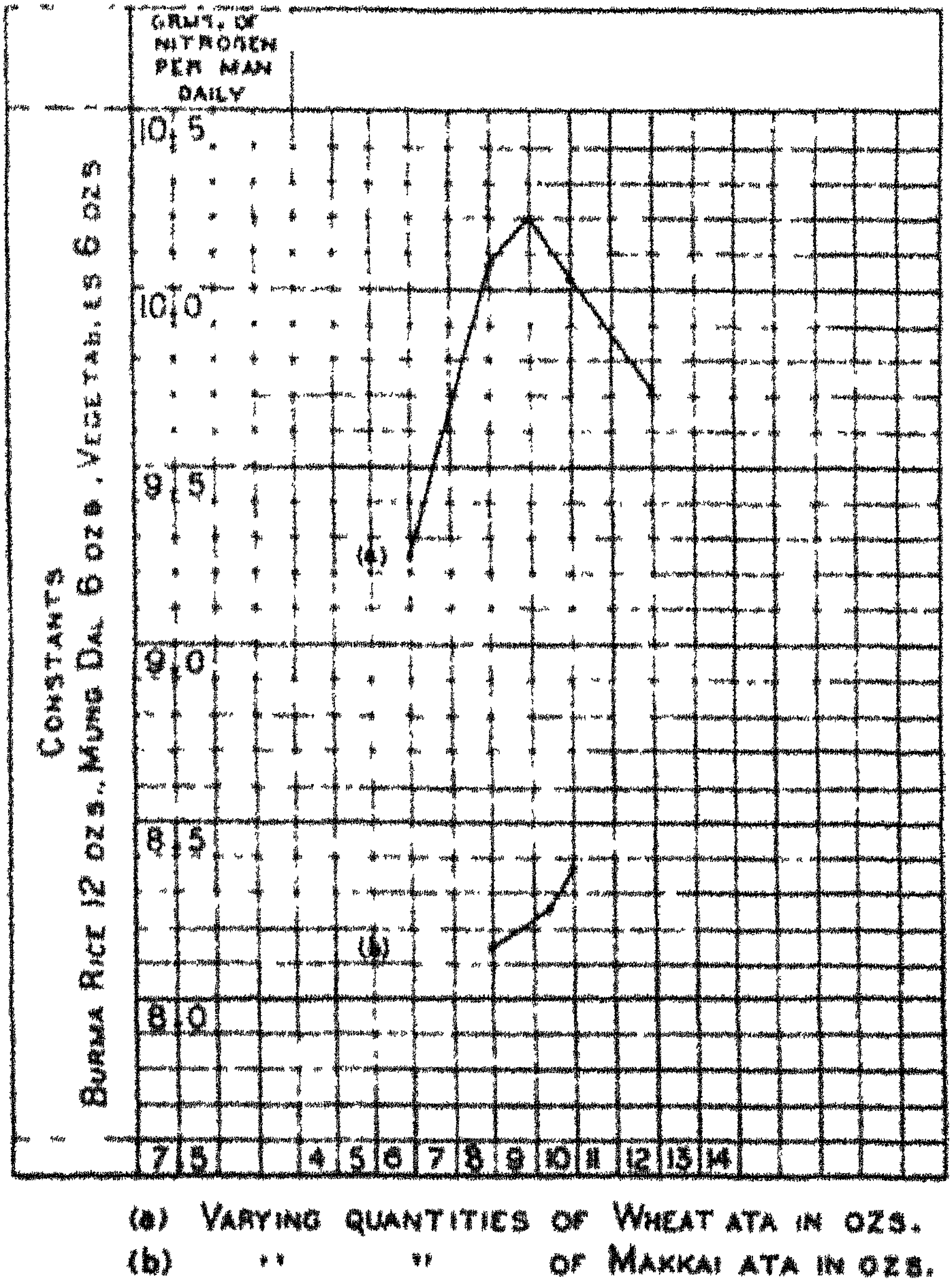
CHART VI.



BURMA RICE IN VARYING QUANTITIES IN OZS.

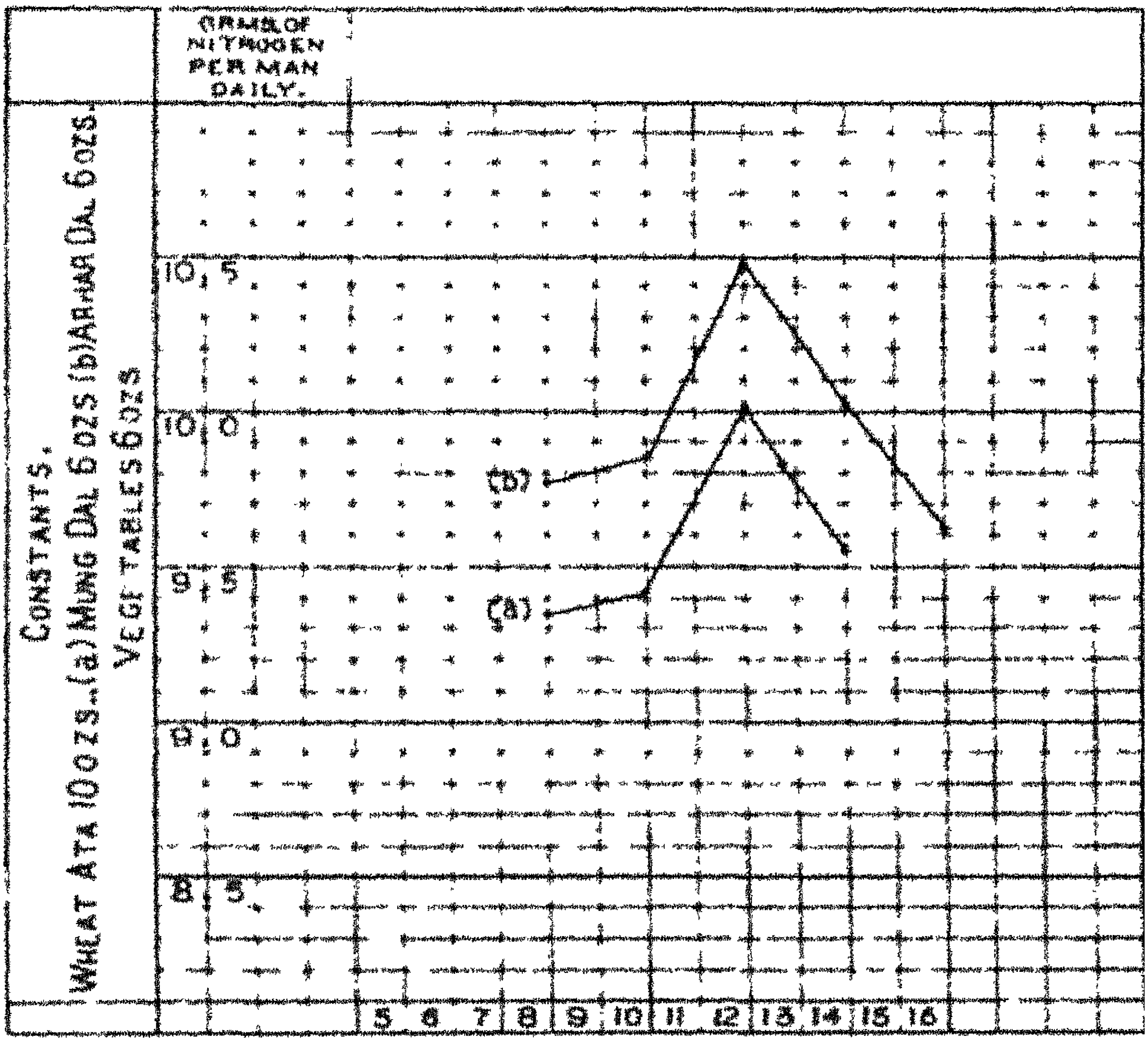
(a) Wheat ata 10 Ozs. Constant.
(b) Makkai ata 10 Ozs. Constant.

CHART VII.



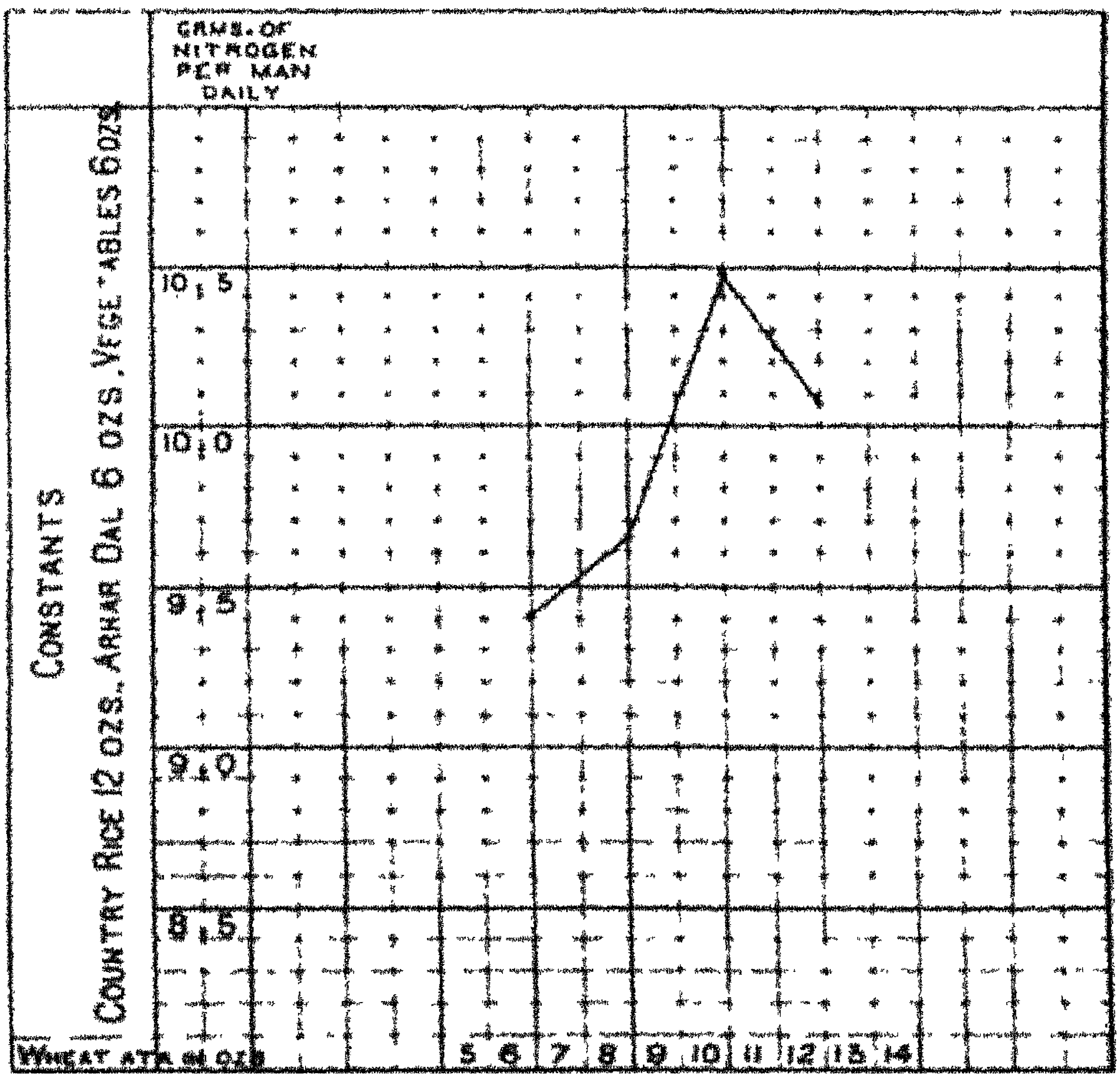
(a) VARYING QUANTITIES OF WHEAT ATA IN OZS.
(b) " " OF MAKKAI ATA IN OZS.

CHART IX.



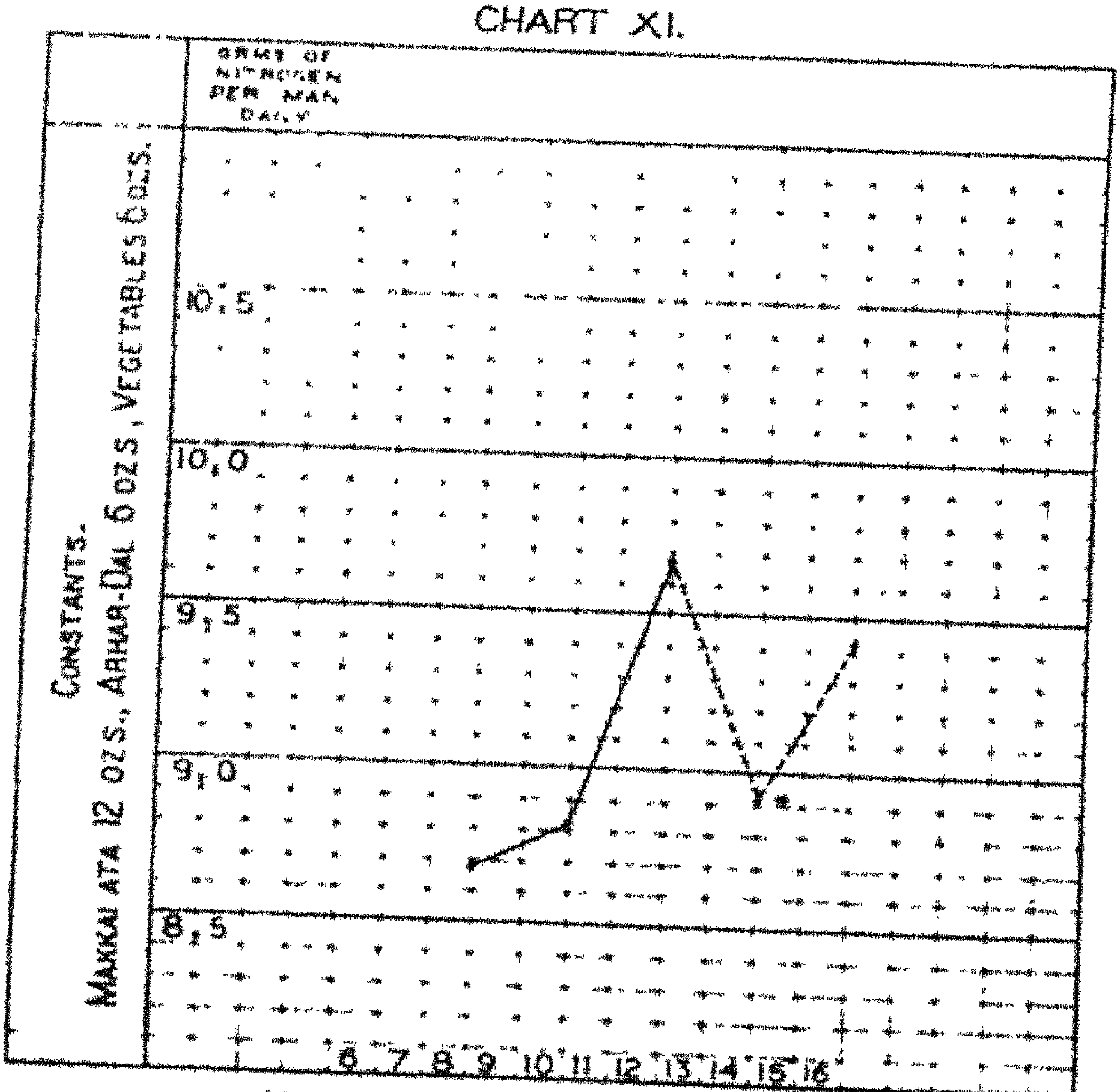
(a) VARYING QUANTITIES OF BURMA RICE IN OZS.
BUXAR JAIL
(b) " " OF COUNTRY RICE IN OZS.
BHAGULPUR JAIL

CHART X.



CONSTANTS
COUNTRY RICE 12 OZS., ARHAR DAL 6 OZS, VEGETABLES 6 OZS
GRMS. OF NITROGEN PER MAN DAILY
10.5
10.0
9.5
9.0
8.5
WHEAT ATTA IN OZS
5
6
7
8
9
10
11
12
13
14

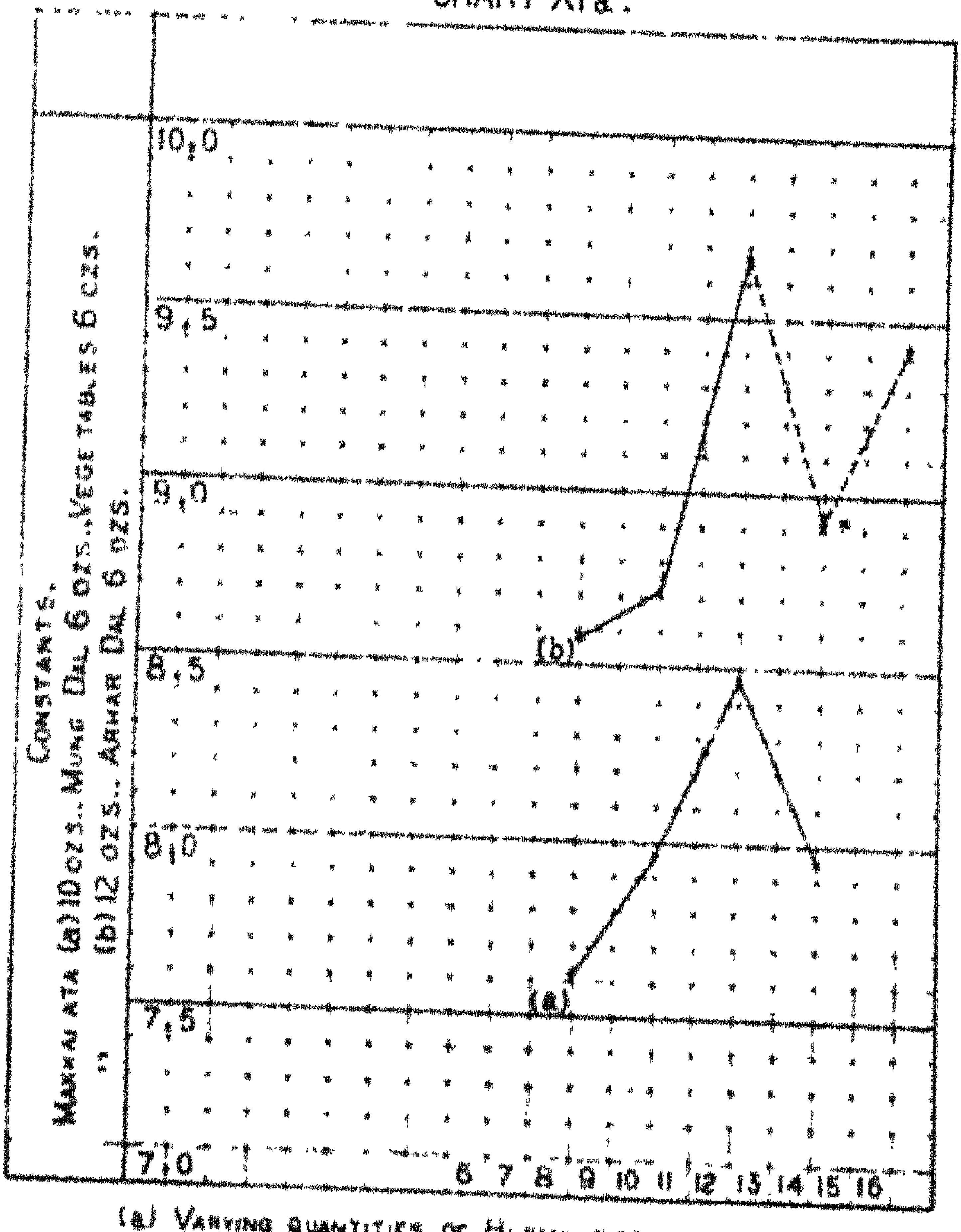
CHART XI.



VARYING QUANTITIES OF COUNTRY RICE IN OZS.

* THE FALL WITH 14 OZS OF RICE WAS DUE LARGELY TO THE FACT THAT ONLY 11 OZS OF MAKKAI ATA WERE CONSUMED IN THAT DIET.

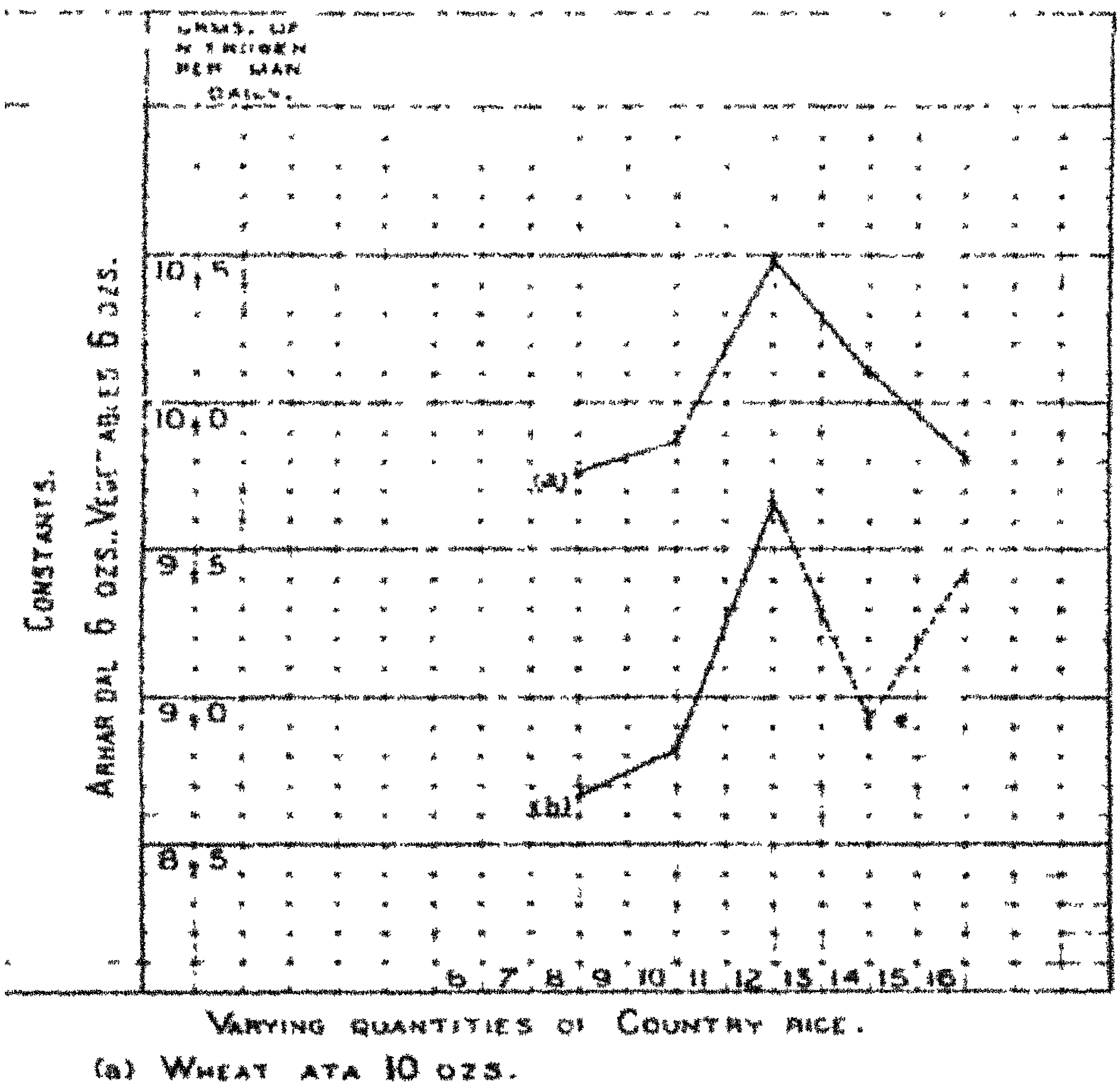
CHART XIa.



(a) Varying quantities of Burma rice in ozs.
(b) Varying quantities of Country rice in ozs.

* The dotted in fall was largely due to the full quantity of makkai ata not being consumed with the diet containing 14 ozs of country rice.

CHART XII.



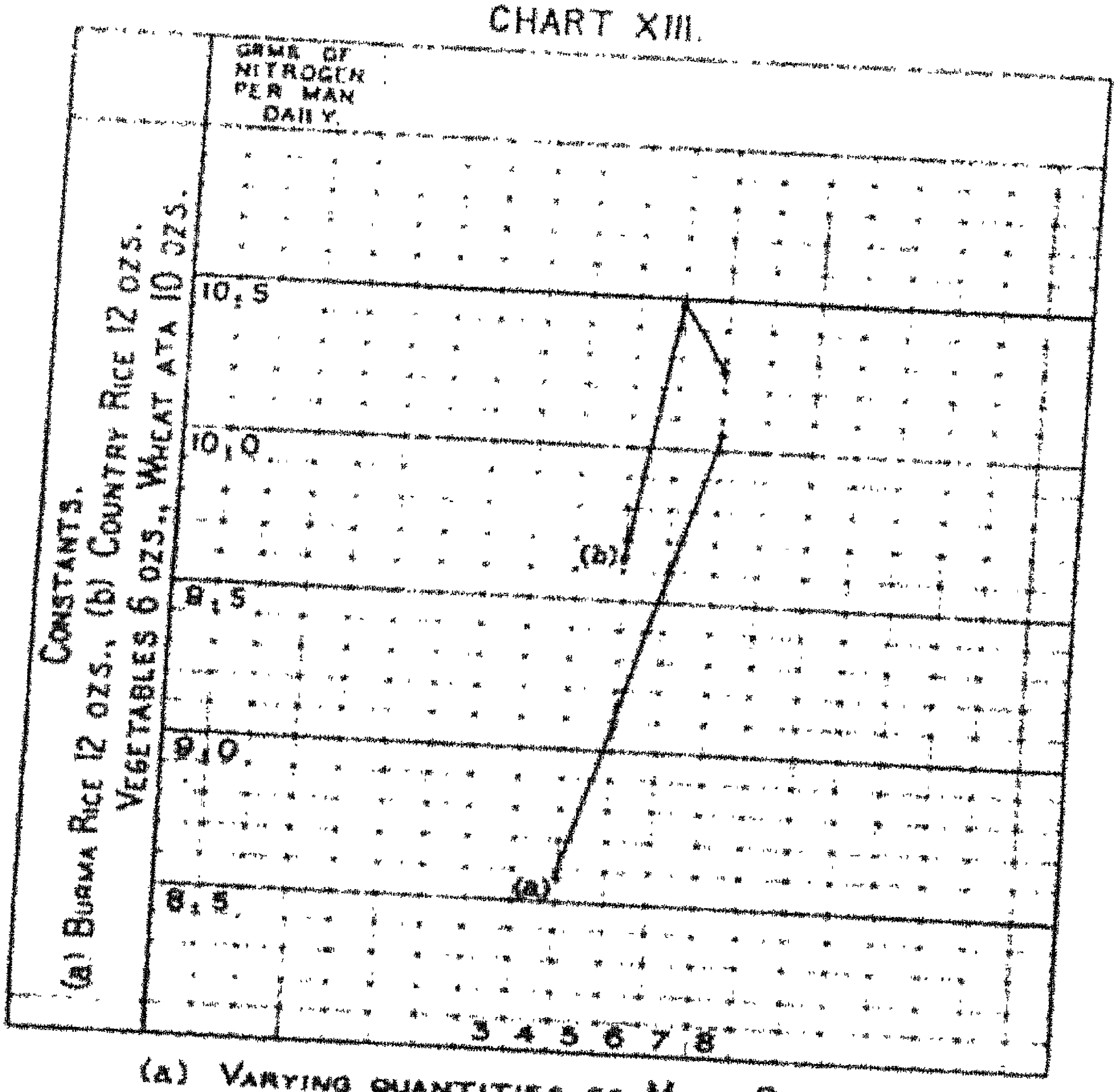
VARYING QUANTITIES OF COUNTRY RICE.

(a) WHEAT ATA 10 OZS.

(b) MAKKAI ATA 12 OZS.

* FALL DUE TO THE FULL QUANTITY OF MAKKAI NOT HAVING BEEN EATEN.

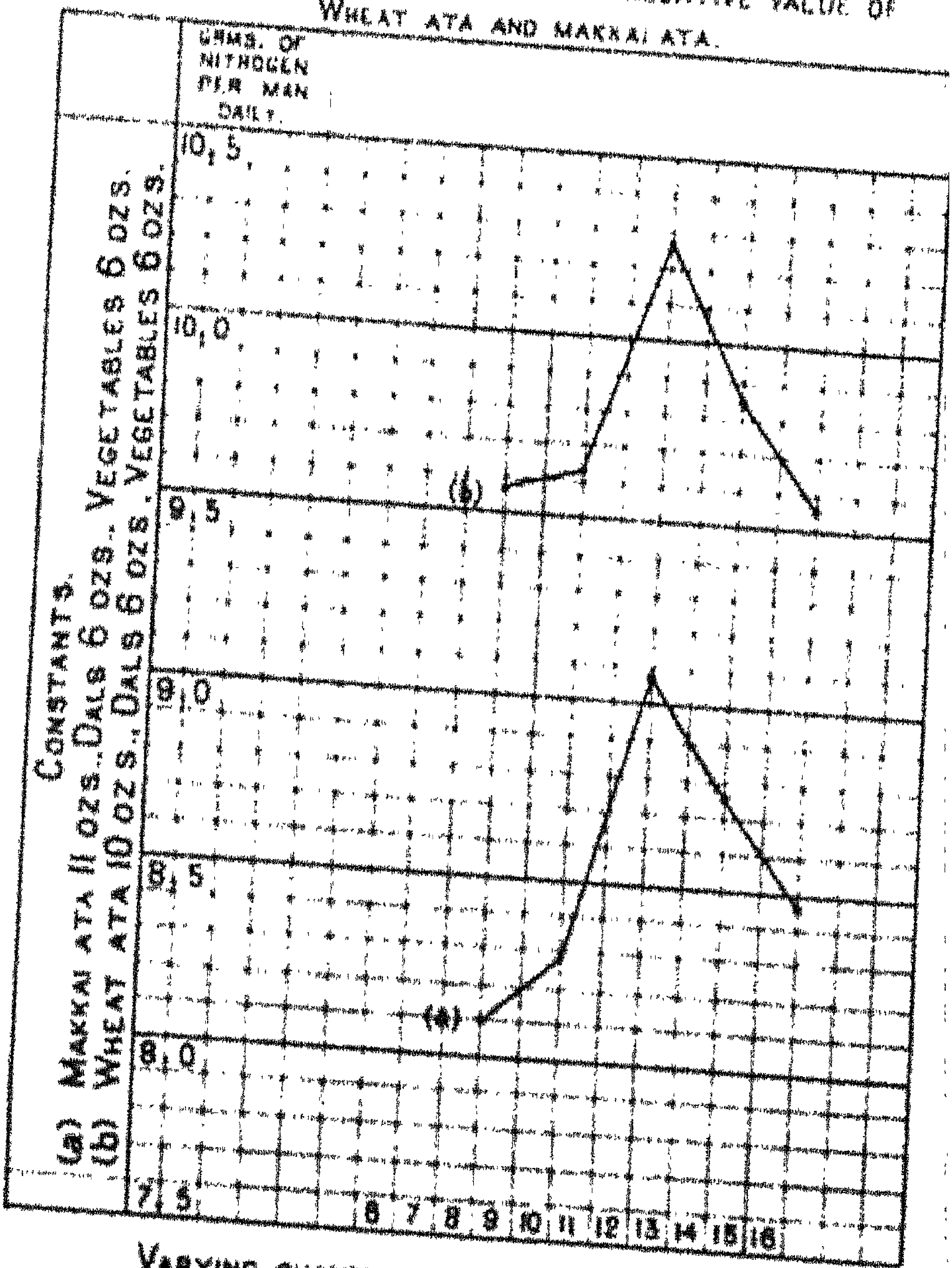
CHART XIII.



(a) VARYING QUANTITIES OF MUNG-DAL IN OZS.
(b) " " ARHAR-DAL IN OZS.

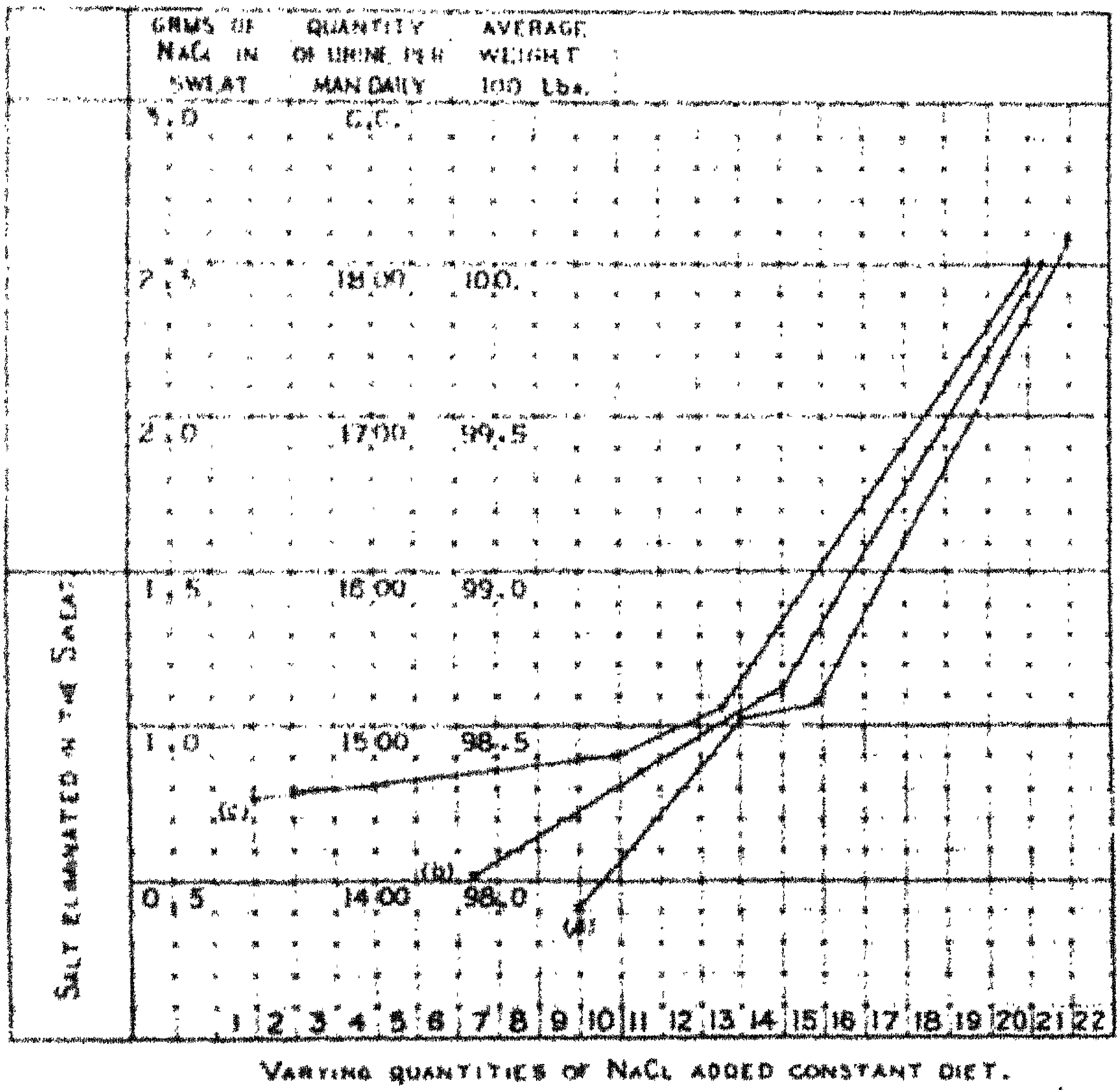
CHART XIV.

COMPOSITE CHART SHOWING THE RELATIVE VALUE OF WHEAT ATA AND MAKKAI ATA.



VARYING QUANTITIES OF RICE IN OZS.

CHART XV.



VARYING QUANTITIES OF NaCl ADDED CONSTANT DIET.

(a) Curve of excretion of NaCl in sweat with varying quantities of salt in diet.

(b) " " " Urine " " " " "

(c) " " Body - weight " " " " "